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Sponsored Research

WHATEVER motive causes a firm to engage in industrial research, whether it be the development of new products, on economic necessity, or simply "to keep up with the Jones's," it is bound to exercise discretion in disclosing its research activities. But, more and more, industry is beginning to realize that without free discussion research cannot flourish. It is for this reason that even the large firms, with more than adequate research facilities of their own, are prompted to pass certain of their researches to other agencies. Equally it is the lack of this realization that prevents many smaller firms from making use of the research and development facilities available to them.

In this country applied research is carried out by universities and technical colleges, Government research establishments and industrial research associations. None of these offers facilities for an industrial firm to have any substantial amount of experimental work of a confidential nature carried on outside its own laboratories. In particular none of them offers facilities to an individual firm for confidenaln research and development likely to lead to exploitable inventions. Such facilities are however, available at independent sponsored research institutes. Originating in the United States, the term "sponsored research" has come to mean confidential research undertaken by an independent organization on behalf of a sponsor who, in return for payment of the costs, retains the full and sole rights to the results of the investigation and to any patents granted. The growth of sponsored research institutes in the United States has been spectacular since the first was founded in 1913, there being today nine major institutes of this type, all of them nominally non-profit making, with a combined annual research expenditure in excess of \$50,000,000. One of them, Battelle Memorial Institute, founded in 1929, now operates two European laboratories. In this country two, wholly British, sponsored research institutes have been operating now for a little over ten years, Fulmer Research Institute at Stoke Poges, and Sondes Place Research Institute at Dorking.

It might be thought that sponsored research is the ideal arrangement for a small firm whose problems are too infrequent to warrant the expense of setting up its own laboratory. Though this may well be true, general experience both here and in America has been that the small firms account for a negligible proportion of the sponsored research carried out. Thus, at Sondes Place, 95 per cent of the work done is for firms with their own research laboratories or for Government departments. There are three main reasons for this state of affairs. First, the desire to bring completely fresh minds to bear on a problem. Secondly, an industrial laboratory, faced with a problem outside the range of its normal activities, finds it cheaper to farm out the work rather than to engage and equip another scientist with the requisite background to handle what may turn out to be a fairly short-term investigation. Lastly, day-to-day production problems so overload industrial laboratories that original research aimed at developing new products or processes is continually postponed because of lack of time.

Establishment of the two British sponsored research institutes ten years ago was something in the nature of an experiment. At the time we ourselves, it must be confessed, were a little dubious that they were really needed or that they would be supported. Their success has amply justified the belief of their founders that sponsored research provides a valuable service to industry.

Out of the MELTING POT

Logical Conclusions

INVENTIONS depending on chance observations of the type "formaldehyde-spilt-over-mouse-trap-cheese=casein plastics" will continue to make their appearance, though probably at ever-increasing intervals of time. Another type of invention will be seen to have been a logical thought process pursued—and therein lies its merit—across existing and firmly established views and practices, to a successful conclusion. A typical example of such an invention is a process for galvanizing small mechanical parts such as screws. According to existing views and practices, this is done by placing the parts in a steel tank containing zinc heated to a temperature approaching 460°C. When coated with zinc, the screws are removed, and vibrated or centrifuged in a basket to remove the excess zinc. Owing to the relatively small mass of the work, cooling is relatively rapid, as a result of which the screws are left with a thick and uneven zinc coating which necessitates the manufacture of the screws with a large clearance in size. The logical trend of thought to which the new process owes its invention can now be seen to have envisaged the use of a higher working temperature which would delay the freezing of the zinc on the work and, at the same time, facilitate the removal of the surplus zinc as a result of the lower viscosity of the molten metal. Cutting across established practice, this trend of thought replaced the conventional steel tank, which would have been attacked by the zinc at the higher working temperatures, by a tank of a suitable ceramic refractory material, in which the zinc bath can safely be heated to 600°-650°C. A further reduction in viscosity of the molten zinc is achieved by the addition of 0·01-0·3 per cent of aluminium. The ease with which the surplus zinc can be removed after galvanizing results in a thin uniform coating. The higher operating temperature also makes it possible to use zinc with a substantially higher iron content so that, in fact, zinc dross can be used, instead of having to make up the bath with pure zinc, as in the conventional method.

Disappointing Sequel

NOT so many years ago, there were still reasonable grounds for concern that the existence of some useful published information might pass unnoticed as a consequence of the inadequacy of abstracting and bibliographical services. To-day, any concern should be aimed in the opposite direction. In fact, however, there is remarkably little evidence of any such concern. In its absence, a situation in which adequate, if not more than adequate, documentation services record "literature," some of which is effectively non-existent, is apparently being accepted with remarkable complacency. There was a time, for example, when Papers to be presented at a meeting of some scientific or technical society were, in fact, just that. To-day, an advance list of such Papers, even when it includes abstracts, does not necessarily mean any such thing. Application, after the meeting, to the obvious source of information—the authors of the Papers—elicits courteous replies ranging all the way from the statement that a particular Paper was never written or presented, through the unfortunate situation in which a Paper was prepared but was then not released for publication, to hopes that the Paper may perhaps be published in from anything from six to eighteen months. How often is one forced to the conclusion that Papers, tantalizingly interesting references to which are found in some brief account of a meeting, were, in fact, nothing more than sonic vibrations at the meeting. Elsewhere, the comprehensive lists of Government and the like research reports, etc., contrast strangely with the difficulty of identifying the various code letters and then trying actually to get a sight of the documents themselves. Elsewhere again, where the information is contained in a journal somebody has taken the trouble to publish in the usual manner, and somebody else has taken the trouble to abstract, how often do repeated attempts to obtain a particular issue lead to the conclusion that it is "not available."

One Better

NOW that powder metallurgy has grown up and acquired confidence, comparisons between its techniques and products and those of the foundry industry are not as frequent and as deprecatory of the latter as they used to be. While some of the earlier unfavourable comparisons between powder metallurgy and casting were concerned mainly with compositions, techniques and products, the equally unfavourable comparison in reverse has to do with the starting material. Compared with the care personally lavished by the foundryman on the molten metal he intends to use (fluxing, skimming, protection against oxidation, etc., and temperature control), the attitude of the powder metallurgist to his starting material is one of remarkable indifference. He is quite prepared to entrust its manufacture to somebody else, to have it (plus a lot of air) transported to his works, and then to take a lot of trouble to squeeze out the air and otherwise to coax the powder into some approximation to the product and properties he hopes to obtain. Admittedly, the manufacturers of the powder can usually be relied upon to know best. Admittedly there exist specifications for composition, particle size range and other properties, which are checked and adhered to. Admittedly, a lot is still being, and remains to be, learnt about making powders to suit the product. All this, however, does not really excuse the powder metallurgist for failing to make any attempt to take matters a little more into his own hands. If the foundryman can go to the expense and trouble of preparing and controlling his own molten metal, there is no reason why the powder metallurgist should not at least consider the possibility of doing the same for his metal powder. In doing this, he could take into account the advantages that would accrue from working in a vacuum and producing clean, active, extremely fine grained powders which could be compacted and sintered without exposure to the atmosphere. What, for example, would be the possibilities of the so-called pyrophoric metal powders, the production and use of which are impracticable with the present arrangements? What would be the effects of the mechanical activation in the case of powders produced by mechanical comminution without a chance of subsequent oxidation and ageing? A pointer to what might be expected is provided by the results achieved by activation sintering as at present applied to "stale" metal powders, a process of which it may be said: "C'est magnifique, but it is not powder metallurgy as it could be."

Skimmer

RELATIVE MERITS OF CHEMICAL HEAT-TREATMENT PROCESSES

Surface Hardening of Titanium in Fused Borax

By A. N. MINKEVICH and YU. N. SHUL'GA

This article describes an investigation, carried out by Russian workers, into the effect of chemical heat-treatments in fused borax and in metallic boron powder on the wear resistance of titanium. It has been translated from "Metallobedeniye i obrabotka metallov."

ONE of the drawbacks associated with titanium and its alloys is that of very low resistance to wear. This disadvantage can be overcome by chemical heat-treatment, but it is not yet clear which of the methods of chemical heat-treatment is the best for industrial use. It is, therefore, necessary to compare the problems involved in the application of these methods and their effects on the properties of the surface layer and the core material.

This article describes an investigation into the oxidation of titanium in fused borax using electro-chemical protection, and treatment in metallic boron powder *in vacuo*.

The materials employed in the investigation were:—
(a) forged titanium, smelted from commercial titanium in a vacuum furnace employing a graphite crucible (this material contained 0·5-0·6 per cent carbon and was designated LS);
(b) forged titanium alloy containing 0·5 per cent tungsten (designated LO.5V) smelted, in argon, from commercial titanium, in an arc furnace;
(c) forged commercial titanium, type VT-1; and (d) alloy VT-2 (2·5 per cent chromium and 2 per cent aluminium).

Fused Borax Treatment

The oxidation of titanium in air at high temperature leads to the formation of a diffusion layer consisting of a solid solution of oxygen in the titanium. This diffusion layer has increased hardness, but the surface of the titanium becomes covered with an oxide film.

With a view to preventing the formation of oxides, tests were carried out on the oxidation of titanium, in fused salts containing oxygen, including fused borax. To protect the surface against destruction by corrosion, electro-chemical protection was employed.

In all the tests (except where otherwise indicated) the current density at the cathode (the titanium sample) was 0·1 amp/cm^2 and the voltage used was 12-15 V. Graphite rods were used as anodes.

On removal from the bath after treatment, the titanium samples were covered with a layer of crusted borax. When the samples were cleansed of borax by mechanical means, their surfaces were light-grey in colour; removal of the borax by prolonged immersion in water caused the surface of the samples to turn dark, and dark friable deposits remained thereon.

The effect of the method of treatment was studied on alloy LO.5V. Increase in the treatment time and the temperature leads to an increase in the microhardness of the surface of the titanium, and the curves relating to the variation in hardness over the depth of the layer show that as the depth of layer increases its hardness is independent of temperature and time of treatment. This behaviour of the curves shows that the diffusion layer is made up of a solid solution of oxygen in α-titanium, the concentration of oxygen in the layer gradually increasing as the temperature and length of treatment are increased.

The results of measurements of the depth of the layer and of the surface hardness of the samples (Vickers—5 kg. load) in relation to the length of treatment at various temperatures, show that the diffusion layer characterized by increased micro-hardness was 2-2·5 times greater in depth than the layer observed under the microscope. Further reference herein to the "depth of the layer" will connote the depth of that layer having increased micro-hardness.

The diffusion layers obtained at all temperatures, judged by the appearance of the indentation caused by the pyramid of the Vickers machine, were found to be relatively free from brittleness. Rubbing of the corners of the samples over a glass surface caused no breaking away of the layer. However, in the case of samples treated at 1,000-1,050°C., appreciable breakage of the outside zone of the layer was caused by even light blows from an object made of hardened steel.

The brittleness of the layer obviously depends upon the concentration of oxygen therein. In this connection, it is not necessary to aim to obtain the maximum concentration of oxygen in the layer; the treatment should therefore be carried out at lower temperatures and over shorter periods.

Tensile tests on samples 5 mm. in diameter and 60 mm. in length were carried out on a Gagarin press. These tests showed that the oxidation o titanium to a depth of 0·3 mm. at 950°C. over a period of 3 hr. causes a sharp reduction in plasticity and some lowering of mechanical strength; tensile strength falls from 88 to 76 kg/mm^2, yield point from 75 to 65 kg/mm^2, elongation from 17·3 to 8 per cent and reduction of area from 40 to 20 per cent.

The mechanical properties of the titanium after treatment are reduced, largely due to grain growth, and at the same time the plasticity is reduced on account of grain growth as well as because of the effect of surface hardening which always sharply lowers the plastic properties of metals.

A still more pronounced reduction in the strength and plasticity of the titanium occurred on increasing the depth of the diffusion layer, not as a result of increasing the period of treatment at a lower temperature, but by raising the temperature to 900°C. which leads to very pronounced grain growth. The chemical heat-treatment should, therefore, be carried out at the lowest possible temperature and on alloys showing a lesser tendency towards grain growth when heated.

Preliminary tests to determine the effect of treatment in fused borax on the wear-resistance of titanium were carried out on a Shkod-Savin machine. The results from these tests (Table I) showed that the wear-resistance of the titanium increases sharply when the treatment time is increased, this is in complete conformity with the increased surface hardness and depth of diffusion layer.

A second series of wear-resistance tests was conducted on alloy LO.5V, using an Amsler machine. This series also covered tests, under identical conditions, on hardened steel, type 45, case-hardened and tempered steel, type 20, and nitrided steel 4 Kh 14N 14V 2M (4 per cent chromium, 14 per cent nickel, 14 per cent vanadium and 2 per cent molybdenum). The tests were carried out without the use of a lubricant and continued for 37 min. only, since the sample of untreated titanium had worn considerably at the end of this period.

TABLE I—PRELIMINARY TESTS ON TYPE LS TITANIUM

Treatment in fused borax	Volume of hole in mm^3 (mean of 2-3 holes measured on one sample)	Volume of hole in untreated as compared with treated samples
Untreated	1473·3	—
930°C. for 1 hr.	775·8	× 2
930°C. for 3 hr.	117·2	×12
930°C. for 6 hr.	39·5	×57

(Carried out on a Shkod-Savin machine; 100 *r.p.m.,* 5 *kg. load, coolant:* 0·5 *per cent solution of* $K_2Cr_2O_7$*)*

TABLE II—TESTS ON ALLOY LO.5V

Material of sample segment	Treatment of sample segment in fused borax	Loss in weight (gm.)		Increase in wear-resistance in relation to that of the untreated titanium
		Sample segment	Collars in steel U12 (Rockwell C=62-64)	
Alloy LO.5V	Untreated (Vickers hardness=290 under 5 kg. load)	0·1986 0·1910	0·0130 0·0212	— —
Alloy LO.5V	950°C., 3 hr. (Vickers hardness=660 under 5 kg. load)	0·0030 0·0064 0·0040 0·0050	0·0030 0·0024 0·0084 0·0082	65 30 48 39
Alloy LO.5V	950°C., 3 hr. (Vickers hardness=660 under 5 kg. load)	0·1489*	0·0973*	—
Steel, type 45	Hardened and tempered (Rockwell C hardness=61)	0·0130 0·0104	0·0084 0·0042	15 18
Steel, type 20	Case-hardened (925°C., 10 hr.). Hardened and tempered. (Rockwell C hardness=63)	0·0099 0·0064	0·0025 0·0032	19 30
Steel 2 Kh 14N 14V 2M	Nitrided at 560°C., 48 hr. (Vickers hardness=800 under 5 kg. load)	0·0055 0·0037 0·0065 0·0061 0·0064	0·0084 0·0100 0·0090 0·0050 0·0035	35 53 30 32 30

**Duration of test on these samples was 5 hr. 20 min.*
Carried out on an Amsler machine. Duration of test: 37 min., load: 25 kg., speed of collar: 200 r.p.m.

TABLE III—CHANGE IN DEPTH AND HARDNESS OF THE BORONIZED LAYER

Treatment temperature	Depth of unetchable zone of the layer (mm.)	Vickers Hardness (5 kg. load)	Micro-hardness (100 gm. load) at various distances from the surface (mm.)				
			0·01	0·025	0·05	0·10	0·15
1,000°C.	0·010	904*	1244	887	504	398	366
1,050°C.	0·011	1030	1583	964	504	400	343
1,150°C.	0·013	1160	2010	1607	512	404	366

**Vickers hardness at centre =350. Treatment time = 6 hr.*

From a comparison of figures given in Table II, it will be seen that oxidation increases the wear-resistance of titanium 30 to 65 times. Even when the period of test of the oxidized sample is ten times as great as that of the non-oxidized one (5 hr. 20 min. as against 37 min.), the loss in weight of the oxidized sample was still the smaller (Table II).

The wear-resistance of the oxidized titanium was found to be greater than that of the hardened steel, type 45, and was equal to that of the case-hardened steel, type 20, and the nitrided steel 4 Kh 14N 14V 2M.

In an X-ray analysis, pictures were taken of flat ground and polished samples without rotation in the 57·4 mm. diameter camera. Copper irradiation was used and the exposure time was 4 hr.

A sample of alloy LO.5V treated at 950°C. for 3 hr. was subjected to examination in layers by X-rays. Pictures were taken at distances of 0·01 and 0·06 mm. from the surface and at the centre. There was found to be a reduction in the lattice parameters a and c (a=2·96; 2·95; 2·94Å, c=2·85; 4·84; 4·77Å). Thus, the X-ray analysis confirmed that the diffusion layer is a hard α-solution.

The boron content was determined by spectrographic analysis for which special reference samples were prepared. The spectrographic analysis was carried out with I.S.1—22 equipment; the width of the aperture was 0·02 mm.; an IG-2 generator provided the excitation source; the distance of the aperture from the source was 28 mm.; the exposure time was 2 min., and a copper rod served as the false electrode.

The spectrographic analysis showed that the boron content in the surface zones of the layers of the variously treated samples was less than 0·1 per cent.

Examination of the microstructure of the treated layers of titanium revealed the presence of bright needles disposed at definite angles and orientated according to the crystallographic directions of the grains of titanium. These needles represent the α-phase. The microstructure and hardness of titanium treated in fused borax do not differ from those of titanium oxidized in air.

Thus, from a study of the results of the spectrographic analysis and examination of the microstructure it can be assumed that, under the experimental conditions, oxygen plays the principal role in the formation of the hard diffusion layer occurring when the titanium is treated in fused borax. This is in accordance with other published data which indicate that increase in the oxygen content of titanium produces a marked rise in the hardness of the alloy and that the maximum possible oxygen content (14·5 per cent) in α-titanium causes the Vickers hardness figures to rise to 950.

Several samples of alloy LO.5V were treated at 1,050°C. and using a high current density (1·5-3 amp/cm²). In this case the diffusion layers had a specific microstructure. With a 1-hr. treatment and a current density of 1·5 and 2 amp/cm², the surface of the diffusion layer was in the form of a compact bright zone adjoining an acicular structure contained in the deeper layers. Near the surface the micro-hardness was of the order of 1,100-1,200 and gradually fell towards the centre; the boundary of the bright zone was blurred. This indicates that the layer in question is in solid solution.

With a current density of 2·5-3 amp/cm² and a treatment time of 3 hr., as a result of a pronounced tendency to go into solution, the samples exhibited an uneven surface and fragments of unetchable incrustations were found on the periphery of the diffusion layer. These surface incrustations had a micro-hardness of more than 2,500 and at their boundaries and at a deeper

zone of the layer, the micro-hardness fell abruptly.

Spectrographic analysis of the surface revealed the presence therein of 12-20 per cent boron. In accordance with the titanium-boron constitutional diagram, with a boron content of up to 18 per cent in the titanium, the phase composition is α+TiB and with a boron content of more than 18 per cent, the phase composition is TiB—TiB_2. Thus, it can be assumed that the incrustations in question consist of a boride-containing phase.

Boron Powder Treatment

Samples of an alloy containing 5 per cent chromium were placed in a porcelain tube and the tube was filled up with metallic boron in powder form. The treatment was carried out in a vacuum furnace type TVV-2 in a vacuum of 10^{-3} mm. of mercury. About one hour was required to raise the furnace to the treatment temperature. The results of the tests on the treated samples are given in Table III.

It can be seen from this Table that as the treatment temperature is raised, the depths of the unetchable zones of the layer increase only slightly but that the surface hardness is considerably increased.

The diffusion layer consisted of three distinct zones, two of which were bright; the outer unetchable zone was sharply separated from the inner slightly etchable zone. The latter merges into the third zone which is dark in appearance. The width of the dark zone is roughly three times as great as that of both the bright zones. The average thickness of the layer as seen on the microsections of samples treated in boron powder for 6 hr. at a temperature of 1,050°C. was of the order of 0·05 mm.

Examination of X-ray pictures of a sample treated in boron powder at 1,000°C. (for 6 hr.) showed that the phase at the surface has a rhombic lattice with the parameters a=6·09Å, b=3·04Å, and c=4·59Å. These figures are indications of a titanium boride (TiB) lattice.

Spectrographic analysis of the surface of the sample showed the presence of 12-16 per cent boron in the surface zones of the layer. This amount represents the average boron content in the layer into which the spark penetrates (to a depth of up to 0·02 mm.). It may therefore be assumed that in the unetchable surface zone the boron content is higher. The second phase in the surface might obviously be an α-phase or TiB (for which more than 18 per cent boron is necessary), but because of the insignificant amount of the second phase it was not possible to reveal it by X-ray means.

Experimental treatment was carried out in a bath containing 60 per cent borax and 40 per cent B_4C as recommended by N. P. Besedin and M. E. Blanter. Alloys VT-1 and VT-2 were treated in this bath.

As a result of the treatment of alloy VT-2 at 930° and 1,000°C. for a period of one hr., its surface hardness rose from 435 to 600 and 820 Vickers' units respectively (5 kg. load).

Of very great interest were the experiments on the treatment of the alloys at a reduced temperature (800°C.) which gives the minimum grain-growth. In this case, the depth of the layer of increased hardness was 0·05 mm. after a 3 hr. treatment and 0·07-0·08 mm. after 6 hr. For a 6 hr. treatment, the surface hardness of alloy VT-1 rose by 220 Vickers units and 420 micro-hardness units, and that of alloy VT-2 by 255 Vickers units and 390 micro-hardness units (5 kg. load on Vickers machine).

Experimental treatment by this method at 800°C. was also carried out in other alloys. These experiments produced roughly the same increase in surface hardness as in the case of alloys VT-1 and VT-2.

It should be mentioned that all the samples treated in the bath containing boron carbide (irrespective of temperature and duration of treatment) exhibited a clean, even, slightly gleaming surface which required no additional grinding and polishing.

Conclusions

Treatment in fused borax and using an electro-chemical method of protection appears to be an effective way of hardening the surface of titanium. With this treatment, the surface hardness (Vickers—5 kg/load) is increased from 250/300 to 700/950. The wear-resistance of titanium oxidized in this way is comparable with that of case-hardened and nitrided steel (tests carried out on dry samples using the Amsler machine).

The treatment of titanium in fused borax lowers its mechanical properties (strength and, particularly, plasticity and ductility); and this is coupled with a pronounced grain-growth of the titanium on prolonged heating, and hardening of the surface.

The treatment of titanium in fused borax may be carried out at 900-930°C. over a period of 3 hr. and using a current density of about 0·1 amp/cm². Treatment at higher temperatures and over longer periods causes a marked increase in the brittleness of the layer and a deterioration in the mechanical properties of the titanium.

The treatment of titanium in fused borax mainly involves an oxidation process, and boronization occurs to only a slight extent or not at all. The bright surface needles formed in this treatment represent a solid solution of oxygen in titanium. Quenching from the saturation temperature does not change the acicular character of the microstructure of the diffusion layer.

On treatment of titanium in fused borax at high temperatures (1,000°-1,050°C.) and with a high current density (1·5-2·5 amp/cm²), a very hard unetchable layer (2,500 micro-hardness units) is formed on the surface of the titanium. Such treatment, however, causes marked breakdown of the surface of the sample.

Treatment of a sample of a titanium alloy containing 5 per cent chromium *in vacuo* in powdered boron at 1,000°-1,050°C. results in the formation of a diffusion layer having a thick unetchable surface zone of great hardness (Vickers 1,000-1,150, micro-hardness >2,200). The type of lattice and the parameters of the surface zone of this layer correspond to TiB. The disadvantage of this method of treatment is the high temperature involved.

The hardening of titanium may be carried out at 800°C. over a period of 6-9 hr., in a bath made up of borax and boron carbide. This method of hardening, however, is only suitable for small parts; also the surface hardness is only increased by 200-250 Vickers units (5 kg/load) and 300-500 micro-hardness units.

Argon Purification Plant

LOW-TEMPERATURE distillation plants for argon purification have been installed during the last few years at Harwell and Aldermaston by the British Oxygen Co. Ltd., and a new plant now being built at Dounreay will be the largest of this type operated by the United Kingdom Atomic Energy Authority.

In this process, impure argon, at sub-atmospheric pressure and containing up to 0·2 per cent by volume of air, leaves the U.K.A.E.A. process and, after admixture with electrolytic hydrogen, is compressed to about 25 lb/in² gauge in a non-lubricated rotary compressor. The argon is passed over a palladium catalyst where the oxygen impurity is converted to water. A recycle circuit allows the hydrogen injection to be controlled to the stoichiometric requirements.

The argon, now oxygen free, is dried by refrigeration in duplicate heat exchangers, cooled, liquefied and separated by distillation into pure argon and a nitrogen-rich fraction which is rejected. In the process, excess hydrogen is separated and is returned to the compressor suction. The purified argon passes back through the heat exchangers to the dry seal gasholder, and thence to the U.K.A.E.A. process. The distillation column and heat exchangers are contained in a compact thermally insulated unit. Refrigeration is provided by the evaporation of liquid oxygen, which is supplied from a standard B.O.C. liquid oxygen plant. This plant is entirely self-contained, and requires only electricity and cooling water services.

The installation purifies 3,300 ft³/hr. of argon and reduces the oxygen content to less than 10 v.p.m. and the nitrogen to less than 40 v.p.m. It will operate for at least 1,000 hr. continuously.

Finishing Supplement

Institute of Metal Finishing

PROCEEDINGS AT ANNUAL CONFERENCE AT TORQUAY

(Concluded from METAL INDUSTRY, *27 June* 1958)

AT the third technical session of the Annual Conference held by the Institute of Metal Finishing at Torquay, two Papers were presented. They were: "Methods of Testing Anodic Coatings on Aluminium," by A. W. Brace, A.I.M., C.G.I.A., and K. Pocock (presented by A. W. Brace), and "Some Aspects of the Growth of Electrodeposits," by H. J. Pick, B.Eng., Ph.D., and J. Wilcock, B.Eng., Ph.D. (presented by J. Wilcock).

The chair on this occasion was occupied by **Dr. G. E. Gardam.** An abstract of the Paper by Brace and Pocock appears below, together with the chief items from the discussion.

Methods of Testing Anodic Coatings on Aluminium

By A. W. BRACE, A.I.M., C.G.I.A., and K. POCOCK

A NUMBER of test methods were evaluated, including Isometer, Filmeter, and electrical breakdown voltage tests for film thickness, SO_2-humidity tests for checking efficiency of sealing, acetic acid-salt spray test for corrosion resistance, and Schuh and Kern abrasion tests.

The investigations showed that some of these were useful and reliable techniques for checking the quality of an anodic coating. Instruments such as the Isometer enable coating thicknesses to be determined rapidly and non-destructively. If the zero calibration is made on an untreated surface of similar curvature, it should be possible to use it on shaped components, although the examination of coatings at sharp bends is impracticable. Instruments indicating thickness from electrical breakdown voltage values are not particularly accurate, especially on thick coatings, and the values on super-purity base materials are very different from those obtained on material of lower purity.

Tests of the SO_2-humidity type appear to be a useful means of acceptance testing for effectiveness of sealing, but some further work is required to standardize test conditions if the test is to be used for specification purposes. The sodium chloride-acetic acid spray test appears to give a useful indication of corrosion resistance. Results on both plated and anodic coatings using 5 per cent sodium chloride and 1 per cent acetic acid, which support this view, have been published, but standardization of the test conditions is called for.

The abrasion test based on the Schuh and Kern apparatus provides a convenient method for testing abrasion resistance. At present any given apparatus yields a useful measure of this property, but results are not quantitatively comparable with those of another laboratory. The work reported indicates the probable steps necessary to overcome this difficulty.

(Trans. Inst. Met. Finishing, **1958, 35,** *Advance Copy, No. 7)*

DISCUSSION

V. F. Henley (W. Canning and Co.):

The sulphur dioxide test, when used on anodic coatings, appears to be a measure of the degree of solubility of the anodic coating in dilute sulphurous acid, which, in turn, has probably a little sulphuric acid present.

As is the case with many chemical reactions, the amount of moisture present has considerable bearing on what happens. To illustrate this point, the General Electric Co Research Laboratories carried out work on the service performance of anodized reflectors. Included in this programme were some reflectors which were exposed in a magnesium foundry on continuous production where the atmosphere was warm and comparatively dry but contained a high percentage of sulphur dioxide, due to the use of sulphur during the melting process. As some of you may be aware, the concentration of sulphur dioxide in such a foundry is almost unbearable. These reflectors showed no attack whatsoever after several months, although so much sulphur dioxide was present.

In contradistinction to that, similar reflectors exposed in a steam railway tunnel near Euston showed very bad attack in seven to fourteen days. Even films of 0·001 in. thickness, properly sealed, showed blooming, and at the end of a month the reflectors were becoming unserviceable, even after cleaning. It seems that the bloom being experienced is purely the result of partial solution of the film; in other words, a limited attack by sulphuric acid.

The use of a little acetate sealing solution, as opposed to hot water, increases the chemical resistance of anodic films. In other words, anodic films sealed in a little acetate are more difficult to strip in either alkalis or esters. Have the authors had the opportunity of trying, or are they proposing to try, the effect of this test on films which have been so sealed?

The B.S. Specification No. 1615 has written into it a fairly simple sealing test, a test for the efficiency of sealing, based on the use of a dyestuff solution. This solution has been known for some years, and probably the most popular form is a solution of anthraquinone violet either in chloroform or some other suitable organic solvent, or in water. In a number of tests with this type of reagent it has always been possible to detect inadequate sealing in different conditions. It seems there should be some correlation between that type of spot test and the sulphur dioxide or humidity cabinet results. Has Brace had an opportunity of checking the two methods, the point being that the spot test is a very rapid workshop method which would serve to deal with day-to day production, and the cabinet would be a useful cross-check to make sure that the standard of production was being maintained?

The acetic acid-salt spray test appears to fulfil a long-felt need for an accelerated corrosion test that bears some relationship to behaviour in service.

C. E. Moore (Ashton and Moore Ltd.):

It is very refreshing to have a Paper on this subject, for no doubt the inception of suitable tests for the user of anodic coatings is highly desirable. Anodizers are in rather an easier position than users. It is not particularly difficult for an experienced anodizer to test his production from the point of view of either thickness or sealing.

Henley referred to the need for some alternative, a rather simpler alternative, as a test of sealing; perhaps something like a dye absorption test or other non-destructive test might be useful, if possible to be correlated with the results now presented.

Much stress should be laid not only on the thickness of film and sealing and the purity of the metal, but also on the metallography of the metal; the pure metal in which the impurities, or the alloy in which the second phase is distributed in fairly large pieces will not, as far as we know, give anything like the same results in corrosion resistance of the resulting film as one in which those other substances are more uniformly distributed. That is only to be expected.

There is, in fact, a marked phase, the body phase as it is called, in which it works round the crystal boundaries and will cause the substance to fail under test, whereas in better distribution that would not occur.

F. C. Porter (Aluminium Development Association):

It is interesting to see in the Paper by Brace and Pocock the corrosion tests

using acetic acid-salt spray show how the corrosion resistance of a film 26 microns thick takes longer than 1,380 hr. On films of only half that thickness the corrosion life is only one-sixth as great. In fact, the corrosion rate goes up rather more than the square of the film thickness. This puts 0·001 in. coatings in a completely different category from most external films which are in existence at the moment, and it should be emphasized to architects and other potential users that they are dealing with something completely different.

It is certainly useful to see that there are two different ways of approach for film thickness and sealing tests, and corrosion resistance tests.

The Aluminium Development Association have drawn up for the guidance of architects an acceptance specification for weather resistance for finishes, and have concentrated on thickness and sealing, and left out corrosion resistance tests. For 0·001 in. film there is too long a testing period at the moment. Further developments of the acetic acid-salt spray test are needed which would enable that period to be cut down either by *p*H or temperature alteration.

J. F. Kayser (Gillette Razors and Blades):

Positive statements are made on far too few of these experiments. On pages 14 and 15 it is stated that the duplicate tests show that the test is reproducible. They do not. Tests such as this should be done at least twenty-five times, and the results should be submitted to statistical analysis.

Then there is the standard deviation and the places. If you are going to use D57S or alloy XYZ, do not just get one bar or strip. Get strips from different casts, and preferably do the experiments in two different laboratories. If we want to make certain of a result, we do the test in London and in Boston, and only then, and after submitting the tests to a statistical analysis, can we, as mass production people, place any reliance whatsoever on them.

Dr. F. A. Champion (British Aluminium Co. Ltd.):

Experience in really severe industrial atmospheres shows that the two important components are, first, SO_2, and, second, chloride. One, therefore, wonders whether the acetic acid addition to salt spray can always be reliable in reproducing industrial conditions.

What are Brace's views on the alternative environment of SO_2 plus chloride, as, for example, by the addition of chlorine to the SO_2 beaker test? There may be objection to that, but the test is limited in capacity. Can the same principles be applied to testing facilities of much larger capacity?

Hydrogen peroxide has been used for a very long time on accelerated laboratory corrosion tests on aluminium in general, and it has been misleading. It does accelerate corrosion a good deal, but other constituents can affect considerably the stability of the hydrogen peroxide and so affect the degree of acceleration. That may not apply to the tests on anodic films where the purer metals are employed, but a warning should be given that there are limits to the use of acceleration.

Dr. T. P. Hoar (University of Cambridge):

Experiments are being done at Cambridge just now to investigate the mechanism of the sealing process, and the general method being used is to measure the capacitance of the unsealed and the sealed panel, and also the variation of the capacitance, the different frequency, on applying alternating current during the sealing process. That gives a curve of a general kind, although it depends on the frequency of the current used.

The capacitance of the film falls after a time, and a very low value is obtained at high frequency. The interest of that with regard to the sealing test method is this. There is presumably the usual kind of pore structure in the film with a barrier layer at the bottom, and this is being filled up in a way not very well known in the sealing process. The capacitance falls because the condenser gets bigger and bigger.

If dyestuff tests are carried out for the same range, the adsorption of the dyestuff is nearly inhibited in this particular form of sealing process after sealing for about 60 sec. The dyestuff does not distinguish between something that is practically unsealed and something that is probably well over-sealed.

It seems to me that the only proper test is a much more pragmatic one of the kind Brace suggests—the SO_2 salt spray test, or something of that kind.

To one who was partly responsible for introducing statistical analysis into metallurgy some 25 years ago, Kayser's remarks were particularly interesting but in Table IV, in which duplicate results are shown, there are six duplicates, all in pretty close agreement. This quite close agreement for some different conditions is rather better than 25 repeats on any one of these tests.

The Chairman: What was meant by "over-sealed"?

Dr. Hoar: The term was meant to indicate a specimen that has gone through a commercial degree of sealing and has been left in the bath for a good deal longer. Something further happens to it, and so far we are not sure what.

R. Wall (Associated Automation Ltd.):

A brief description of the test used by an anodizer might be of interest. In particular, considerable trouble occurs with a duplicating machine which uses an aluminium alloy moistening roller. This machine uses a commercial methylated spirit for the wetting agent, which is pumped from a canister made of brass, tin plated. Within the pump there are a stainless steel ball valve, phosphor bronze spring and brass tube, and a rubber flex. This takes the fluid on to a spray, which goes on to a felt pad that is in contact with the aluminium roller.

In use it was found that, due to dissolution of metal from all these containers, the metals are concentrated over a period of time in the felt pad. There was considerable pitting on the line of contact with the pad, particularly when the machine was left idle. The whole machine was taken apart to test the quality of the anodic film, and at one stage a change-over to another material was considered.

Although the potassium iodide-iodate test has not been accepted, we introduced it as a porosity and anodic production test, for use on the shop floor, the roller anodically and the aluminium cathodically, using a Whatman filter paper and a modified solution. The paper was soaked and put between the two, and six volts was passed through it. If there is porosity it shows at once in the typical iodine, and if it is badly sealed there is an iodine stain.

AUTHOR'S REPLY

A. W. Brace: The real point now is that, the case having been established, the evidence can be considered by the British Standards Institution Committee and by other users. They can all get together and begin to broaden out the testing on the basis of much wider co-operation, satisfactory to all, after sufficient tests have been done and sufficient specimens collected to see that the tests really mean something.

Henley pointed to the beneficial effects of nickel acetate in sealing. Tests have been made with nickel acetate sealed panels, and although an improvement was apparently detected, the exposure testing (the improvement was detected in an accelerated test) has not shown a very marked superiority for the nickel acetate sealed panels. It is slightly better, but not sufficient.

As a matter of interest, however, sealing in potassium dichromate does markedly improve the corrosion resistance of anodic coatings, even in industrial atmospheres. One is not surprised by that in marine atmospheres, but there has been a definite improvement in industrial atmospheres. Unfortunately, there is the very distinctive yellow colour which, in many circumstances, is objectionable.

A number of people have referred to spot tests, particularly the use of dyestuffs and so on. On the whole, our results tie more closely with those of Dr. Hoar and his colleague, although the period has been found very slightly longer than he indicates. In the first five months of sealing at boiling point the ability to absorb any dyestuff disappears. As the temperature goes down, the effect becomes slightly more marked, but it is usually necessary to get below 80°C. before it becomes really marked and perceptible. Our experience has been that the SO_2-humidity test is much more sensitive and discriminating in these respects.

The real point is that there is not any really sharp boundary between bad sealing and good sealing, not that there is a continued increase in resistance. We believe that sealing of the anodic coating involves converting it to böhmite. It has already been established by several workers that the higher the temperature formation in the böhmite the lower its solubility, and, in turn, the better the corrosion resistance. Our experiments in that direction seem to bear out those observations quite nicely. Fingerprint tests, dyestuff tests, and so on, are a useful workshop way of checking against really bad practice, but the SO_2-humidity test will prove to be even more discriminating.

Porter referred to 0·001 in. films. It is very doubtful if it is going to be practicable to get a test that will give an overall corrosion resistance answer in a short time. If you have a coating on which exposure experiments (not, surprisingly, corrosion resistance) have already been done, when the whole thing is stepped up to produce rapid breakdown, a number of other factors are introduced which tend to make it, not a measure of true corrosion resistance, but simply a form of measurement of

chemical resistance under particularly severe and unusual conditions that have little relation to service life.

With an acceptance test for a very thick coating, the most one can do is to introduce a relatively short-term test to ensure that the worst has not happened. There is good evidence that as long as the thickness test and the 24 hr. SO_2-humidity sealing test is conformed to, the rest of the business is pretty well guaranteed, and the results can be relied on.

There is one way in which the tests do not entirely fill the bill. The corrosion resistance of an anodic coating is very much influenced by the anodizing conditions. It is hoped to publish later some work in this direction, but some of the results may be quoted.

These are results on D57S exposed in East London. For example, it was found that if we anodize in a 1·6 *N* heavily acid electrolyte at 60°F., and a 10 micron film thickness is produced and exposed at 45°C. without cleaning, definitely observable pitting occurs in 14 months. On the other hand, if the anodizing temperature is increased to 80°F., a similar standard of pitting can occur in only three months. If one uses a slightly stronger electrolyte, a 3 *N*, with the same film thickness, it is 12 months before this standard of pitting is reached with the electrolyte at 60°F. and three months at 75°F. It is when one comes up against factors of that kind that this combination of film thickness and SO_2 testing may fall down.

Some more work is being done on the acetic salt spray test to see how well it helps to reveal the influence of factors such as this. There is certainly some indication that it helps, but there is not sufficient data at the moment on which to take any particular stand. The question is an important one, because we are coming more and more round to the opinion that the trend will be increasingly towards using weak sulphuric acid electrolyte, higher anodizing voltages and, probably, relatively lower temperatures.

Dr. Champion raised an interesting point. He suggested that consideration might be given to a modification of the CRL beaker test by adding chlorine to it. We have done no work on this. It would be interesting to know how long it takes to get a result on that sort of test, and how the pattern compares with that produced out of doors. It may have some attraction, but from a commercial point of view one would need a larger apparatus than the CRL beaker for practical production tests. One often has to test components and not small test panels, and it is too small. It would mean designing a new apparatus on similar lines.

It was thought that if a similar test to that used on plating could be used—and it is not unreasonable from theoretical and practical considerations—then it is not a bad thing to do. On the whole, these results have justified that. From the point of view of the industry there are many people who do plating and anodizing, and it is a nuisance if an extra piece of equipment has to be obtained to do whatever job of finishing is taken on. It seems, therefore, that there is probably scope in both directions.

Dr. Hoar plotted a capacitance curve. It is most interesting because it proves to be the inverse of the weight increase curve. It would be interesting to compare the capacitances of böhmite films produced by direct reaction with the aluminium against what is thought to be böhmite produced in an anodic coating. In particular, it would be interesting to see what happens with very thin films where one is comparing films of similar thickness and characteristics.

There is some evidence that the continuation of the sealing time will slightly improve corrosion resistance, and commercial practice may try to compromise beween these effects. But the slope of the curve and the rate of rise are very dependent on the characteristics of the electrolyte. With a very strong, heavily acid electrolyte, like 20 per cent by volume at 75°F., one kind of curve tends to result, and with a relatively weak solution there is another kind of curve. The old rule of sealing equals anodizing time tends to break down if you want to be critical. At least 20 min. is preferred for most purposes, and with thicker coatings at least 30 min.

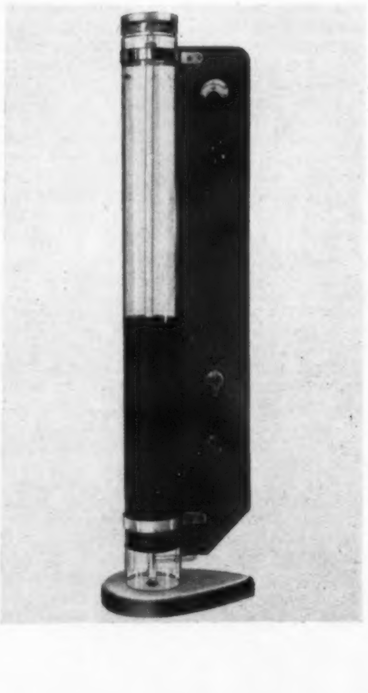
The potassium iodide iodate method will show up really bad sealing but again, from limited experience, does not appear to be as discriminating. There should not normally be gross porosity in anodic coatings. The very nature of the mechanism of formation of anodic coatings should give freedom from that unless there are major material defects to contend with. And if this is so, the finisher often has to make the best of the job he is given. But the problem is not in the processing, but in the original material. This is a point worth bearing in mind: that there is a definite limitation on the value of this test, because normally one should not meet with gross porosity of the kind that can be detected by this test, given reasonable processing conditions.

Industrial Water

WATER having a specific resistance within the range 3-15×10⁶ ohms is finding an increasing application not only in the laboratory but also in industry, where such water is used in the preparation of pure chemicals and in the washing of components subsequent to treatment with acids and other electrolytes.

An example of the importance of water purity is given by the following instance, which occurred a short time ago.

One of the largest manufacturers of transistors in the country noted with concern that the percentage of rejects of complete transistors remained alarmingly high, notwithstanding every effort to bring it down to reasonable limits. The cause, unsuspected in the early stages of the failures, was ultimately located in the water used for the washing and rinsing of germanium components.



Plant was already installed for the production of deionized water but, being piped through stainless steel ducting, the water acquired sufficient ions to raise its electrical resistance, and contamination of the parts resulted. The remedy was the installation at each point of application of a small mixed bed deionizer which, since almost pure water was being fed into it, gave, per unit, some thousands of gallons of completely pure water.

Water produced by simple distillation almost invariably contains significant traces of metal ions, dissolved carbon dioxide and silica, and has a *p*H value which is always less than 7 and often as low as 5·9.

The removal of ionic impurities by adsorption on mixed cation and anion exchange resins provides the best possible solution to this important problem, and this method is widely used in large-scale processes.

A process enabling mixing and reclassification of the resins to be carried out in columns down to 3 in. in diameter is used in the Griffin-Raleigh water deionizer, made by Griffin and George Ltd., of Alperton, thus making it a simple matter to regenerate the resins *in situ*.

The cost of pure water made with this apparatus is only 12s. 6d. per 1,000 gal. when used on London mains supply. A built-in amplifier and a bridge circuit incorporating a conductivity cell enables effluent quality to be monitored, and the circuit is independent of mains voltage and temperature fluctuations.

The Griffin-Raleigh water deionizer is supplied ready for use in two sizes, giving 16 and 64 gal. of very pure water per regeneration respectively. Using mains water, flow rates of 5 and 20 gal/hr. may be employed with an effluent conductivity of 0·2 micromho. Using as influent either single distilled or two-bed deionized water, the effluent conductivity may approach 0·05 micromho, and an inter-regeneration capacity of several thousand gallons is realized.

CLEAR SOLUTION FOR WIDE RANGE OF CURRENT DENSITIES AND DEPOSIT THICKNESSES

Bright Silver Plating

BRIGHT silver electro-deposits are desirable for many applications, including both decorative and industrial finishes, and to meet this need the Baker Platinum Division of Engelhard Industries Limited, 52 High Holborn, London, W.C.1, have recently introduced a bright silver plating process.

The special features claimed for this process include: Mirror-bright finish through a complete range from flash to heavy deposit. Deposits are hard (V.P.N. 135) and highly ductile. The clear, water-white solution enables the plater to watch work in the process of being plated; parts accidentally falling into the tank can be recovered and possible contamination avoided. Uniformly good results can be obtained with current densities ranging from 10 to 40 amp/ft^2. Organic contaminations can be removed by filtration through activated carbon. Non-critical, economical operation and control. Brighteners completely stable, with no deleterious decomposition products. Solution possesses excellent throwing power. Room temperature operation reduces the tendency of carbonate build-up and fumes.

The solution comprises a high cyanide bath with special brighteners added. The normal bath composition is as follows: fine silver, 5·3 oz. troy/gal.; potassium cyanide, 14·4 oz/gal.; potassium carbonate, 2·4 oz/gal.; *p*H, 12·3 approx.

Solution Maintenance

Silver cyanide. The silver content should not be allowed to drop below 4·5 troy oz/gal. Below this figure, because of lack of sufficient silver ions, the tendency for dullness at the high current density areas will increase. By increasing the silver content above the recommended figure of 4·5 troy oz/gal. higher current densities may be used. During operation the silver anodes maintain the silver content. Sufficient anodes should be used in the tank so that the anode current density does not at any time exceed about 12 amp/ft^2. A ratio of cathode to anode area of 1 to 2 is highly desirable.

Potassium cyanide. To obtain optimum brightness, it is important to maintain the free cyanide at a minimum of 12 oz/gal. Below this value there is a tendency for dullness to develop in regions of low current density.

Potassium carbonate. When a new bath is made up, potassium carbonate is added to improve conductivity and throwing power. As in all cyanide baths, carbonate builds up. The carbonate content may reach a value of 12 oz/gal. without noticeable adverse effect.

The *p*H should be kept in the range of 12·2 to 12·5, optimum being 12·3. This is also important when the bath is idle for relatively long periods. Cyanide solutions are more susceptible to decomposition at *p*H values below 12 than above. The brighteners used in this process are highly stable above *p*H 12·2; below 12·0 there is some tendency for decomposition to occur. Since normally any adjustment required would be upwards, for purposes of calculation, 1 gm. potassium hydroxide added per gal. solution raises the *p*H approximately 0·1 *p*H unit.

When a new bath is made up, but not otherwise, Baker Basic Brightener No. 1 is added (3 gal. per 100 gal.), no further additions being necessary. It is a highly stable material.

Baker Replenishing Brightener No. 2 is the active additive for maintaining bright deposits. Additions are made up on the basis of the number of ampere-hours passed through the solution, i.e. 100 c.c. of brightener are added for every 100 ampere hours. To simplify control it is highly desirable to have an ampere-hour meter of requisite capacity connected in series with the plating circuit, so that ampere-hours used may be read directly from the meter. Replenishments, based on the above formula, should be made daily for consistently good results.

Operating Conditions

Under normal conditions, that is, about room temperature (77°F. to 80°F.) and where agitation with a moving cathode bar arrangement is used, cathode current densities of 15 to 20 amp/ft^2 give excellent results. With increased agitation and higher silver content, current densities as high as 40 amp/ft^2 are possible.

For the best results it is recommended that a temperature of 77°F. to 80°F. be used. There is a tendency at higher temperatures for the deposit to lose brightness in areas of low current density which may be compensated for by an increase in the current density. As is the case with all cyanide solutions, high bath temperatures cause more rapid loss of cyanide, and thereby increase in carbonate concentration; also, cyanide fumes become a problem.

A stainless steel immersion heater placed between anodes and side wall of the tank, to avoid stray currents, is suitable.

The most suitable method of providing agitation is by means of a moving cathode bar arrangement. In addition, particularly in cases of continuous operation, moderate circulation of the solution by means of a pump (this may be provided when continuous filtration is used, as described in the ensuing paragraph) is most desirable.

Keeping the solution free from suspended matter is highly important to avoid roughness of the deposit. Although continuous filtration should be used for the best results, periodic filtration suffices for many cases. A stainless steel filter and pump should be used, or one covered with a vinyl coating. P.V.C. tubing is recommended for hose.

It is very important to use anodes of the highest quality to obtain optimum brightness. Good results have been obtained with conventional anodes, but Baker dog bone anodes are recommended for best results.

An approved type of lining for highly alkaline solutions is necessary. White tygon lined tanks are recommended. With a white lining the work in process of being plated can be readily observed, and current adjustments made by the operator to obtain the best results. The cleanliness of the tank and solution, and condition of the anodes, may also be observed, and the solution more easily kept at top operating efficiency.

The use of deionized water is strongly recommended, particularly where the water supply is hard and is likely to result in precipitation of magnesium and calcium salts.

Plating Procedure

The ordinary procedure used in silver plating is to be followed. A silver strike is necessary and is made up as follows: silver cyanide, 0·3-0·5 oz/gal.; potassium cyanide, 12 oz/gal.

Trouble can be avoided by using chemicals of good quality. Approved grades of silver cyanide should be used. The potassium cyanide should be free of sulphur. During operation, impurities may get into the tank and cause dullness and other undesirable effects to develop. In some cases, electrolyzing the solution for several hours with a cathode dummy at about 5 amp/ft^2 may be effective. Certain types of organic contaminants causing trouble may be effectively eliminated by filtering the solution through activated carbon. Filter continuously until the tank solution has been turned over several times. After it has been ascertained that the impurities have been removed, the filter should

be cleaned out, since if activated carbon is kept in the filter too long, there is a tendency for the absorbed impurities to be released into the solution again.

Barrel Plating

Excellent results can be obtained in bulk plating by the barrel method. In general, the same composition is used as in regular tank plating. Because of the relatively large drag out, the silver concentration may drop to as low as 3 oz/gal. and good results may still be achieved. However, for the best results from the standpoint of brightness and highest permissible current density, the standard concentrations as indicated are recommended.

After complete solution of all the chemicals the analysis of the bath should show the following: silver metal, 5·3 troy oz/gal.; free potassium cyanide, 14·4-16·8 oz/gal.; potassium carbonate, 2·4 oz/gal.; *p*H, 12·3 approximately.

Research for Industry

AT an open day on July 11, many examples of the work being done by the Sondes Place Research Institute were on show. Several of these were of interest to the non-ferrous metals industry, and, although some of the work of the Institute is confidential, the following may be mentioned.

Work on ion exchange membranes, sponsored by the National Research Development Corporation, is part of a joint N.R.D.C/D.S.I.R. programme aimed at developing new and improved ion exchange membranes and equipment for industrial applications of electrodialysis.

Two main problems are being investigated: (a) development of new membranes and methods of making them on a large scale; (b) operation of pilot electrodialysis units and investigation of the chemical engineering problems of using electrodialysis for purification and recovery in the industrial field.

Physical methods of analysis are being investigated, including gas chromatography and its uses. A preparative gas chromatographic column is under development. It handles quantities of the order of 20-30 gm/day and is being converted to automatic operation. Other work in this field includes U.V. absorptiometry, flame photometry, and miscellaneous physical measurements.

The high temperature materials laboratory is concerned mainly with diffusion processes for producing coatings on metals resistant to oxidation at very high temperatures. Vapour plating processes, such as siliconizing, chromizing and boronizing, were demonstrated, together with test methods on oxidation resistance, thermal shock resistance, and wear resistance.

Diffusion coated metals and alloys have potential applications to gas turbine blading, to wear-resistant machined parts and chemical plant where advantage can be taken of their excellent chemical resistance.

Vapour diffusion coatings can be produced in controlled thicknesses and applied after all the major machining operations have been completed.

X-ray diffraction techniques are widely used for solving practical problems, and the "finger print" method of identifying unknown materials from their diffraction photographs was demonstrated.

For the high-temperature work on various materials there is a Stott gas-fired furnace for operating temperatures up to 1,900°C.

The Institute, which is at Dorking, is sponsored by industry and carries out confidential research and development on behalf of its clients. Much of its work, however, is carried out with the collaboration of the Government-sponsored laboratories.

Corrosion Resistance of Titanium

WITH an exceptionally high strength / weight ratio, and resistance to many highly corrosive environments, titanium is a major constructional material for many industries.

Although not a noble metal, it has excellent resistance to either general corrosion or to pitting attack by most salt solutions, and reasonable resistance to some mineral acids. This resistance to corrosion, which would not be expected from fundamental considerations, is due to complex surface chemical reactions and electrochemical polarization. Outstanding environments in which titanium is normally resistant are sea water, ferric chloride, cupric chloride, nitric acid, chromic acid, and acetic acid. Resistance to many mineral acids, hydrofluoric acid excepted, can be increased by the addition of suitable acid salts or oxidizing acids.

Data on this aspect of titanium are contained in the Information Sheet No. M811, issued by Wm. Jessop and Sons Limited, Brightside Works, Sheffield 9, and resistance to a number of organic and inorganic environments is detailed. The data are primarily compiled from laboratory tests on commercially pure titanium (Jessop qualities Hylite 10 and Hylite 15).

Stain-Free Drying

FOR the rapid drying of metal articles, a new technique has been introduced by Imperial Chemical Industries Ltd. Metal parts are treated in trichloroethylene to which has been added a special additive, "Trisec," that ensures freedom from staining even of bright plated and polished parts.

"Trisec" has been specially developed to be effective at moderate temperatures so that advantage can be taken of the low heating requirements of trichloroethylene. The effect of the additive is to displace the water film on the metal surface by trichloroethylene, which readily evaporates.

The treatment is most effectively carried out in simple equipment similar to a standard LV2 or LV3 I.C.I. degreasing plant, but incorporating a water separator and extra free board above vapour level, and fitted for rim ventilation. One compartment —the one containing "Trisec"—is used for the drying operation and the other for the subsequent rinsing of the dried parts in pure boiling trichloroethylene. This ensures that the articles are not only perfectly dry, but also quite free from grease contamination. The whole process is normally completed in about 1 min.

Any article which can be degreased in an I.C.I. liquor-vapour degreasing plant can be dried by using "Trisec," provided that the appropriate type of basket, jig, or other handling equipment is used. As with any drying process, it is necessary to ensure that the work has been well rinsed in clean water before it is introduced into the plant.

The process is very much faster than traditional drying processes. It is applicable to parts of intricate shape where water may lodge in recesses or be held by capillary attraction. The size of loads is limited only by the need for easy manipulation; an LV2 plant (effective size of compartments 20 in × 9 in × 10 in. deep) will handle up to 30 loads of 30 lb. each per hr.

Work need only be left in the "Trisec" compartment long enough to reach the temperature of the solvent—usually 20 to 30 sec.

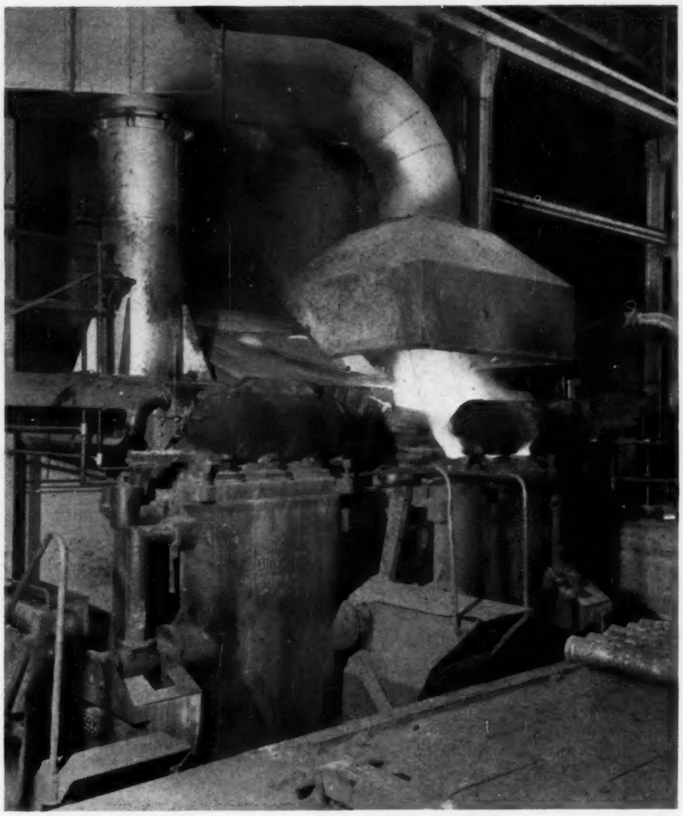
Obituary

Mr. H. A. Campsall

WE regret to record the death of Mr. Herbert Atkinson Campsall. He was, for 29 years, secretary of Wilson and Jubb (Leeds) Ltd., lead smelters and manufacturers. Mr. Campsall, who was 76, was formerly on the staff of T. G. and J. Jubb, of Leeds, and had been associated in business with the Jubb family for 51 years.

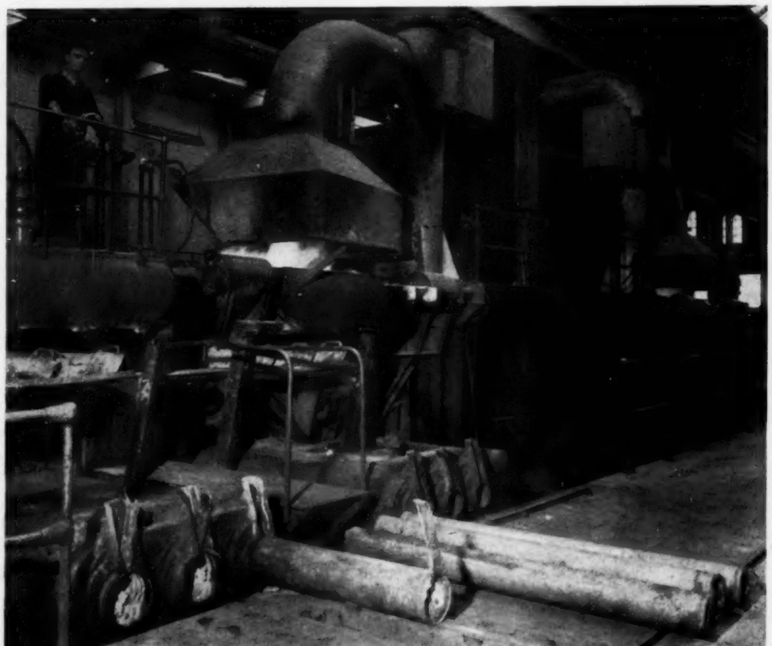
Chill Cast Brass Billets

INSTALLATION FOR EXTRUSION BILLETS AT DELTA METAL COMPANY LIMITED



Above: Pouring from one of the 2-ton Ajax-Wyatt furnaces into the Brookes billet casting machine at Delta Metal Co. Ltd.

Below: After cooling the billet moulds are tipped to a horizontal position and hydraulic rams eject the billet



DURING the past few years the business of The Delta Metal Co. Limited has been greatly expanded, and the company has had some spectacular successes in obtaining new business for brass extrusions in the export field—notably in North America.

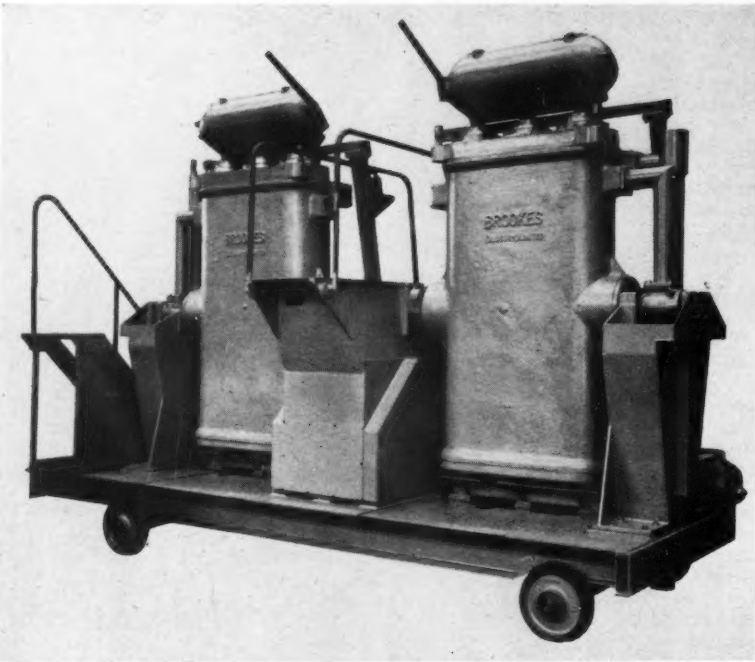
To meet these increased demands, a new plant for the production of chill cast billets, mainly to B.S.S.218 and 249, but also, on occasion, in other alloys, was put down last year at The Delta Metal Co. Limited, Dartmouth Street, Birmingham, and went into full production a few months ago. One of the most recent installations of its kind, it incorporates some interesting features and represents a considerable technical advance over conventional billet casting foundries.

Two items of equipment form the principal features of this foundry, the Ajax-Wyatt furnaces and the Brookes chill-casting machines. These and their associated equipment and controls have been installed in a shop almost entirely rebuilt to house them.

The furnaces, supplied by Electric Furnace Co. Limited, of Weybridge, are of 2-ton capacity, and follow the design of the well-known Ajax-Wyatt low frequency induction furnace, with twin coils and hydraulic lip tilting mechanism. Power is supplied to each furnace from a 720 kVA 3-phase Scott-connected transformer which breaks down the supply from 11,000 V. 3-phase to 600 V. 2-phase, supplying 360 kVA for each coil, the current being approximately 600 amp.

Charges for the furnace are brought to the loading platform by special heat trucks carried by monorail crane. These trucks or skips have a forward swing door operated by trigger release, to facilitate furnace feeding. To ensure consistency of quality, and adherence to specification, every melt is sampled, and subjected to laboratory analysis.

Melting rate is approximately 2 tons/hr. per furnace, and pouring is effected via "trouser-leg" launders into specially-designed bowls or hoppers above the billet moulds. During pouring, the fume hood of the furnace is



The Brookes double triple-casing billet casting machine, prior to installation, showing the truck on which the machine is traversed from the pouring to the ejection station

swung forward so as to be over the pouring position.

Tilting is by hydraulic rams, and one of the features of the installation is that the rams are fitted with telescopic splash guards or shields to avoid damage should any splash or spillage of molten metal occur. The moulds are protected against casting without water by the installation of a safety device in the form of an interlock between a visible water flow relay unit and a solenoid valve incorporated in the hydraulic system.

One of the problems associated with chill casting is the avoidance of turbulence, and where multiple moulds are being used, as in this case, a further difficulty arises in ensuring that all moulds are filled at the same time. These difficulties have been overcome at Delta by a two-fold system: (1) the "trouser-leg" launder and hopper, and (2) the provision of spill-trays.

The "trouser-leg" launder is designed so that each leg feeds into the hopper at a point midway between the exit spouts (of which there are three). This tends to reduce the circular motion that would occur in the metal in the hopper if only a single launder were used and, at the same time, ensures closely proportionate flow from each of the spouts of the hopper, whence the metal flows into the moulds. The sizes of the spouts from the hopper are arranged differentially as a further aid to equal filling.

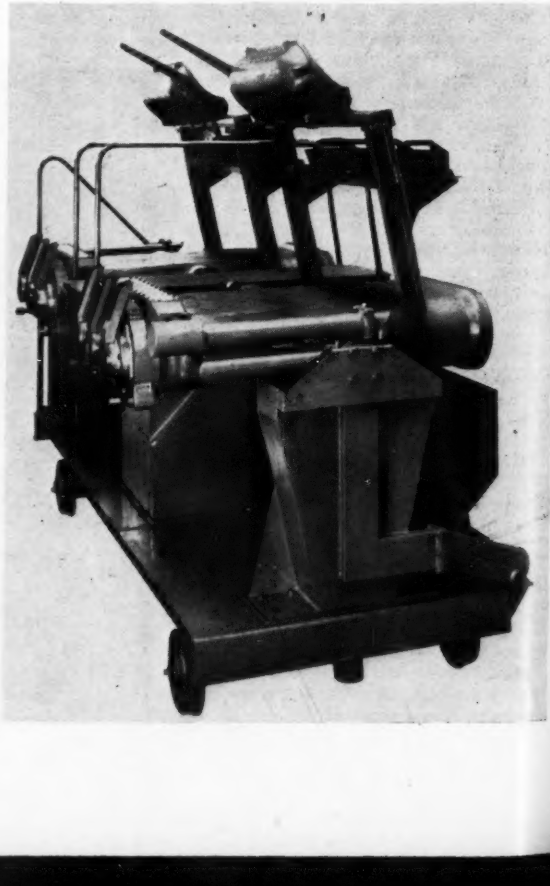
Moulds are of the copper-lined water-cooled type, each mould being 6 ft. 5 in. long, for billets of 7 in. or 8½ in. diameter, as required, and are arranged in sets of three, two sets to each billet casting machine (supplied by Brookes (Oldbury) Ltd.). During pouring, they are held in the vertical position, the three moulds being poured simultaneously, as indicated earlier. Pouring is continued until all three moulds are at overflow point, splash trays being provided to take up any overflow from a mould that may fill slightly before those adjacent to it. After one set of moulds has been filled, the billet casting machine is traversed electrically across the front of the furnace to bring the second set of three moulds into position beneath the "trouser-leg" launder.

After a sufficient lapse of time for cooling, the billet casting machine is traversed into position for the billet to be ejected, the moulds being tipped electrically to a horizontal position for this operation.

Each of the moulds has a seal or bung at its lower end, which is placed in position while the mould is empty and in its horizontal position. As the mould is brought to the vertical for pouring, these bungs are pressed against a cam which secures them firmly during filling. They are then freed again as the mould resumes its horizontal position prior to ejection.

In the ejection position, the bottom end of each mould is brought opposite a hydraulic ram, and as this ram is operated it forces the now chilled billet out of the mould upon a skid rail on the foundry floor. The billets then pass along to a saw, sunk in the floor adjacent to the furnaces, where they are cut to length before being taken to the extrusion shop.

Control of the ejection operation, including the hydraulic ram and the traversing mechanism for the billet casting machine, is effected by push buttons mounted on a control panel at the side of the moulds and behind the



The billet casting machine with the moulds in the horizontal (ejection) position

ejector mechanisms. Electrical equipment (transformers, etc.) and the hydraulic pump units, are mounted in a room constructed beneath the charging platform of the furnaces and at the rear of the furnace bodies.

Cooling water for an installation of this size always presents something of a problem. In this case, the problem has been met by the provision of a closed circuit system, consisting of a 10,000 gal. tank placed on the roof of the building from which water is gravity fed to the mould casings and also to the primary coils of each furnace. It then flows into a 3,000 gal. tank sunk in the floor of the shop, from which it is pumped back to the roof tank. The level in the floor tank is automatically controlled, and as the predetermined level is reached, a "Londex" relay switches on the pump motor and surplus water is taken up to the roof.

To economize in the use of water, a cooling device has to be used in the circuit, consisting of spray coolers, and, in addition, the installation of a Heenan and Froude cooler is expected to start very soon.

Two pumps are used, and these are interconnected so that if one or the other should fail the alternative pump will function as required. As a further safety measure, in the event of both pumps developing faults, audible warnings are used to alert furnace crews.

It is, perhaps, the care with which the pouring devices and the control mechanisms have been designed that makes this installation of particular interest, and the successful achievement of satisfactory triple-mould pouring, the incorporation of more-than-adequate safety devices, and the correlation of furnace operations, billet casting machine controls, and cooling water supplies, is itself a tribute to the close co-operation between Delta and the two main suppliers that attended the initiation of the design.

The Delta Company was the originator of the extrusion process in this country, and has always taken a pride in the high quality of its brass extrusions. This new plant is designed to maintain this high standard by the employment of the most up-to-date techniques.

Hydraulic Pressing

HIGHER output in heavy pressing operations is one of the advantages claimed for the new range of four-column hydraulic presses being produced by Charles S. W. Grigg Ltd., of Hanworth Road, Hounslow, Middx., a member of the engineering division of the Triplex Safety Glass group of companies.

By incorporating a pre-fill valve submerged in the oil tank, it has been made possible to bring down the platen to the pressing position at high speed. Another feature is a very fast return stroke. The approach speed, return and pressing speeds can be adjusted to suit requirements; the approach speed being controlled by a conveniently placed reflux valve.

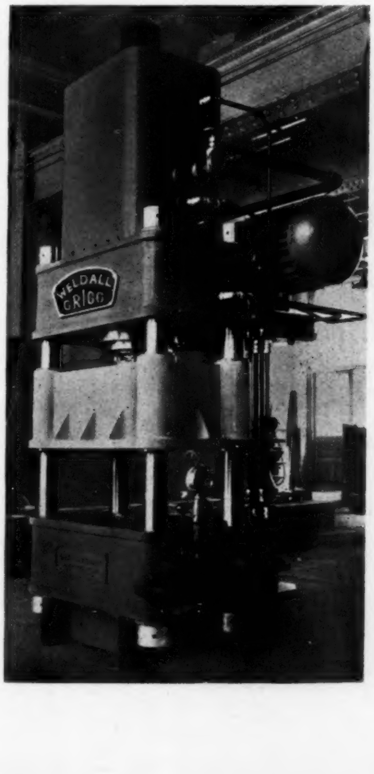
Daylight stroke and bed areas can be varied to suit individual requirements.

The machine is completely self-contained, the pumps, oil tanks and some other essentials all being housed in the crown. The design is being used to produce presses ranging in capacity from 50 to 5,000 tons.

A substantial improvement in the degree of control of the moving platen has been secured by using extremely long guides. This gives complete rigidity and stabilizes any off-centre loading. The guides, moving the platen and the bed, are steel fabrications, annealed prior to machining. The double-acting cylinder is machined from a solid steel billet and finished by honing.

Working pressure on all the Weldall-Grigg presses is 2 tons/in^2, using hydraulic pumps, valves and ancillary equipment supplied by Towler Brothers (Patents) Limited, of Rodley, near Leeds.

One of the range of four column hydraulic presses manufactured by Charles S. W. Grigg Limited



Men and Metals

A director of the Sheffield Smelting Company Limited, **Mr. G. P. Felstead** has been admitted to the Freedom of the City of London. He is a member of the Worshipful Company of Goldsmiths.

Executive director of British Oxygen Gases Limited, **Mr. J. Strong,** M.A., has been elected President of the Institute of Welding for 1958-59 in succession to **Sir Charles Lillicrap,** K.C.B., M.B.E. The following have been elected vice-presidents of the Institute:—**Mr. A. Clifford Hartley,** C.B.E., B.Sc., M.I.C.E., **Mr. G. Roberts,** B.Sc., M.I.C.E., and **Mr. E. Seymour-Semper,** M.I.Mech.E.

To succeed **Mr. G. M. Menzies** as chairman of the British Steel Founders' Association, **Dr. C. J. Dadswell** has been elected. **Mr. C. H. Kain** has been elected vice-chairman.

It has been announced by the Board of Trade that the **Earl of Halsbury** will retire from the position of managing director of the National Research Development Corporation on March 31 next year to take up another appointment. Appointed temporary adviser to the Board of Trade in May, 1949, in anticipation of the establishment of the Corporation, the Earl of Halsbury was the first managing director of the Corporation.

At a meeting of the directors of the National Industrial Fuel Efficiency Service, held last week, **Dr. W. Angus Macfarlane** was unanimously appointed as managing director of N.I.F.E.S. Prior to joining the organization in 1954 as its chief executive, Dr. Macfarlane was Scientific Attaché at the British Embassy and head of the United Kingdom Mission in Washington.

Formerly Chief Cashier to the Bank of England, **Mr. P. S. Beale** has been appointed a director of the British Oxygen Company Limited.

At the annual meeting of the American Society for Testing Materials, held in Boston recently, the Charles B. Dudley Medal was awarded to **Mr. John E. Dorn, Mr. Thomas A. Trozera,** and **Mr. Oleg D. Sherby,** for their Paper entitled "The Effects of Creep Stress Histories at High Temperatures on the Creep of Aluminium Alloys," which was given at the 1956 annual meeting. Awards of Merit were also presented to **Mr. Clifford P. Larrabee,** of the Applied Research Laboratory of the U.S. Steel Corporation; **Professor Fritz V. Lenel,** Department of Metallurgical Engineering, Rensselaer Polytechnic Institute, Troy, New York; **Mr. Bourdon Francis Scribner,** chief of Spectrochemical Section, National Bureau of Standards; **Mr. Louis Jacob Trostel,** manager of Research Laboratories, General Refractories Co., Baltimore; **Mr. Vincent P. Weaver,** assistant metallurgist, The American Brass Co., Waterbury.

Multi-Layer Plating on Titanium

A METHOD of plating titanium and its alloys that involves briefly the deposition of four dissimilar metals, has been developed by North American Aviation Inc., Downey, California.

Because it has no tendency to chip or peel, the multi-layer plating is frequently applied prior to the fabrication of titanium in order to prevent galling and seizing during forming. It can also eliminate scaling during heat-treatments, facilitate soldering, and permit the reclamation of over-machined parts.

Good plating on titanium is not easily accomplished. Chromium plating, for instance, is an excellent solution to the galling and seizing problem in theory; yet the best chrome plate will fail under moderately high bearing loads if applied to bare titanium surfaces.

To give the required characteristics, the new process involves plating nickel, copper, silver and gold successively.

Nickel is first applied by means of an electroless or chemical reduction method in order to obtain a base coating with optimum mechanical adhesion to titanium. Copper is used primarily as a base for the adherent deposition of silver, which is functionally the most important part of the finish, and the final gold coating prevents silver oxidation.

Fatigue tests made with commercially pure titanium parts thus plated have been conducted at 50 per cent of the yield strength at temperatures ranging from $-100°$F. to $700°$F. Similarly, tensile tests have indicated no detrimental effects that might be attributed to plating.

Adhesion tests amounting to hundreds of cycles have failed to cause peeling or cracking, and coatings on bend test specimens have remained intact up to the point where parent materials failed.

For practical purposes, parts with areas ranging to 5 ft^2 and 6 ft^2 have been both internally and externally finished without difficulty. At the time of writing, there had been no titanium rejects due to plating since the new process was formally approved for production usage.

Plated titanium is particularly important in missile construction because it permits the efficient use of the parent metal's excellent strength-weight ratio in parts which must conduct current in the 200 to 400 megacycle bands, where depth of current flow is 150 to 200 millionths of an inch.

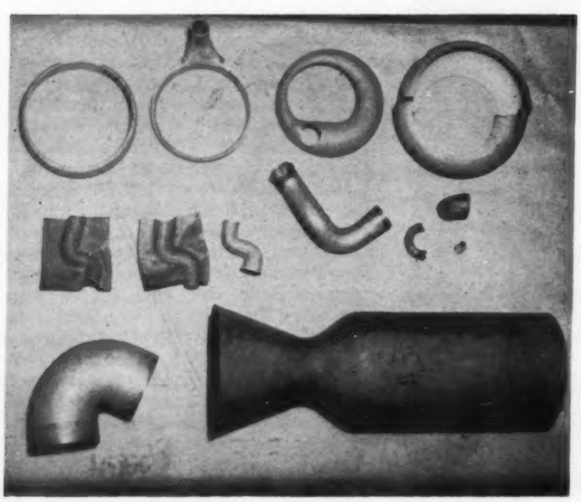
Where no high structural strength is required, plated titanium parts can be satisfactorily utilized at service temperatures well above 900°F.

Pre-processing is especially critical in the preparation of titanium for plating, since it is necessary to remove thin oxide films as well as conventional surface contaminants. Where all oxides are removed immediately prior to the initial plating operation, parts go into an electroless nickel solution with a layer of nascent hydrogen atoms, which play a catalytic role and assure the proper bonding of deposition materials.

A standard electroless process developed by Chemplate Company, Los Angeles, has to date been used with good results in producing nickel plating on titanium. Electroplating methods subsequently employed in the deposition of copper, silver, and gold are also more or less conventional.

Following their removal from the nickel plating bath, parts must be transferred to all following strike and electroplating solutions as rapidly as possible in order to minimize the possibility of coating contamination.

Nickel and copper coatings are applied as layers with thicknesses ranging from 0·001 in. to 0·002 in. The depth of silver plating may range from 0·002 in. to 0·0025 in., while the final gold coating is only about 0·000050 in. thick.



Above: Titanium sheet being immersed in electroless nickel bath

Left: Typical parts formed from titanium after plating. The plated coatings facilitate fabrication and heat-treatment

Industrial News *Home and Overseas*

Ultrasonic Drilling

During a recent visit to Italy, Mr. P. B. Aces, sales manager of **Airmec Limited,** was successful in negotiating an agency agreement with Apparacchi Scientifici Federici of Milan for the exclusive rights to market their ultrasonic drilling and ultrasonic medical equipment in the United Kingdom.

The ultrasonic drilling equipment is stated to provide a unique method of cutting intricate patterns on ceramics, metals, and a variety of materials by interposing an abrasive suspended in liquid between the tool and the workpiece, under pressure, and subjecting the whole to ultrasonic vibration. The abrasive acts on the workpiece to cause minute fragmentation to occur and erode the workpiece to the pattern provided by the tool.

New Midland Office

In order to ensure that expansion of business does not adversely affect their service to Midlands customers, **Fielden Electronics Limited** have established a permanent Midland area office in Walsall. The address of this new office, which is under the management of Mr. F. B. Price, is 51 Bradford Street, Walsall, Staffs.

Copper from Eire

According to news from Dublin, the first shipments of copper ore from Avoca, Co. Wicklow, Eire, are scheduled to go through the port of Arklow within the next few weeks to Britain and Sweden for smelting. Development and refining work is at present going on at the mines, operated by the Saint Patrick Mining Company Limited, and about 520 men are employed.

Jetties have been built at Arklow, some six miles away from the mines, to accommodate the loading of the ore. So far, about 100,000 tons of ore have been stockpiled at Avoca.

Atomic Energy Exhibition

At next September's "Atoms for Peace" Exhibition in Geneva, a determined effort will be made to show the world what Britain has achieved in the field of nuclear engineering. Seventy-nine British firms will occupy stands in the space reserved by the Nuclear Energy Trade Associations' Conference of Great Britain. The exhibition will open on September 1 and remain open until September 14.

Among the British exhibitors will be the following firms:—A.P.V.-Paramount Limited; Cambridge Instrument Company Limited; Dawe Instruments Limited; Elliott Bros. (London) Limited; Imperial Chemical Industries Limited; The Mond Nickel Company Limited; Mullard Equipment Limited; Newman, Hender and Company Limited; T.I. Nuclear Engineering Limited; U.K. Atomic Energy Authority; Vickers Nuclear Engineering Limited; General Electric Company Limited, and Head, Wrightson and Company Limited.

On the metallurgical side of the exhibits there will be seen finned fuel element cans made of special alloys, heat exchanger tubes of many types, and wrought or fabricated products from metals such as zirconium, titanium, tantalum, beryllium, niobium and vanadium. On one stand will be shown a specimen of uranium concentrate containing over 80 per cent of uranium oxide from the mines of a British company.

Changes of Address

As from Monday next (July 21), **Aluminium (Canada) Limited** will be housed in new premises at Aluminium Canada House, 30 Berkeley Square, London, W.1. The company's telephone number and cable address will remain the same.

It is also announced that **Kelvin and Hughes (Industrial) Limited** will move their administrative offices from 2 Caxton Street, London, S.W.1, to their new building at Empire Way, Wembley, Middlesex, on Monday, August 11 next. Their new telephone number is Wembley 8888.

New Research Laboratory

Now being built at Stevenage, the new D.S.I.R. Laboratory is to be called the **Warren Spring Laboratory.** It will be recalled that the Council for Scientific and Industrial Research expressed the view that this new laboratory should be a versatile station, free to do work on any subject which becomes important for the nation and which cannot be fitted into the programme of another research body.

It has already been decided that work will be carried out on air pollution, on the syntheses of oil and chemicals from carbon monoxide and hydrogen, and on mineral processing. The new station will, in addition, be free to take up any research requiring staff and facilities of the type that are being provided.

Norwegian Nickel Production

Sole nickel producer in Norway, the Falconbridge Nikkelverk A/S, Kristiansand, is continuing to increase output. It is stated that production is now running at a rate of around 24,000 tons annually, compared with 21,000 tons last year and only 10,000 tons in 1950. During the first four months of this year the plant produced 7,800 tons of nickel, compared with 5,700 tons in January-April last year. Nickel exports from Norway in the period amounted to 7,100 tons, worth 92 million crowns, against 5,600 tons, worth 91 million, in January-April last year. More than 60 per cent of the exports went to the United States. West Germany took nearly 900 tons, Sweden about 700 tons, and the U.K. 650 tons.

The firm also produces several thousand tons of electrolytic copper annually. Falconbridge Nikkelverk A/S is a subsidiary of the Canadian concern Falconbridge Nickel Mines Limited. The raw material treated at the Kristiansand plant is nickel-copper matte imported from Canada.

Engineering Drawing

A new scheme under the above heading has been introduced by the **City and Guilds of London Institute,** and college courses will be commencing in the new session. This has been designed to provide a good background qualification to enable the engineering apprentice to become a draughtsman, and it is intended that students with a variety of backgrounds should qualify for entry to the course, which is based on two years of part-time instruction. This is not a designer's course; the designer's needs are more appropriately met in Subject 60, Mechanical Engineering Design.

The course includes applied mechanics, mathematics and geometry, materials and processes, and there is throughout an emphasis on practical drawing. Students who have followed National Certificate (Mechanical) courses to S.3 level, or obtained Intermediate certificates in machine shop engineering, or appropriate Final certificates, may enter the course. There is a further provision for older students with a background of drawing office experience. No candidate, however, will be admitted to the examination who has not attended the specified course of instruction.

Full particulars of the above scheme are available on application to The Director of the Institute, Gresham College, Basinghall Street, London, E.C.2, and enquiries should be marked "B.5."

Colliery Year Book

Just published is the 36th edition of the "Colliery Year Book and Coal Trades Directory," which presents, in a convenient and reliable form, the fullest information on the coal mining and allied industries. The data in the standard and statistical sections has been thoroughly revised and, in addition, to information on the coal mines in Western Europe and the U.S.A., which has been a feature during the past few years, details of coal mining in Poland and the U.S.S.R. are now included.

Full particulars of every coal mine in Great Britain are given, together with current information regarding the Ministry of Power and the National Coal Board, and the Mines and Quarries Regulations 1957 with the 1957 amendments. The book covers 876 pages and is published at the price of 40s. net (by post 42s.) by Iliffe and Sons Limited, Dorset House, Stamford Street, London, S.E.1.

Industrial Safety Week

During the year 1956 some 22,548 persons were absent from work as a result of injuries following falls, equal to 14·1 per cent of all reported accidents. This figure does not represent the total number of falls in industry, as it does not include any accident where a person was absent only for the remainder of the shift or day on which the fall occurred. Even minor falls can cause a serious hold-up of production, for, in addition to the injured person being out of action, several others may cease work for various reasons. The prevention of falls is, therefore, a matter of major importance to management apart from the humanitarian aspect.

The Royal Society for the Prevention of Accidents feels that everyone employed in industry should be reminded that **Extra Care Stops Falls,** and has, therefore, adopted this slogan for this year's National Industrial Safety Week, which is to be held from September 29 to October 4. The campaign will have the active support of the 51 industrial

accident prevention groups in the country, and the society has provided a wide range of publicity material for the occasion. Full particulars of the campaign may be obtained from the offices of the society at Artillery Mansions, 75 Victoria Street, London, S.W.1.

A Summer School

During last week, **Metropolitan-Vickers Electrical Company Ltd.** held its Summer School, the seventh in the series of Easter and Summer Schools which the company inaugurated in 1928. This year's school has been for professors and heads of university departments in engineering, physics and metallurgy, with an attendance of over seventy representatives.

In addition to talks and discussions on a wide variety of subjects, the arrangements included tours of the principal departments of the company, and visits to the M-V Wythenshawe transformer works and the Manchester University radio telescope at Jodrell Bank. The large attendance and the keen interest of all members left no doubt as to the value of the school to principals in the field of technical education.

Aluminium News

Some interesting notes on the various uses of aluminium appear in the latest issue of the bulletin published by Aluminium Union Limited. The German Standards Association has given official approval to aluminium helmets for fire-fighters and other industrial workers, following scrupulous tests by the German Institute for Chemical Technology. These helmets are reported to be 40 per cent lighter than their steel counterparts, and provide equally good head protection.

A 12½-ton, four-section, cast aluminium chuck assembly is stated to be in use by North American Aviation Inc. It is part of a table to hold wing panels for precision milling. The chuck is 28 ft. long, 130 in. at the widest point, and 16 in. deep. The heaviest casting is 3¾ tons.

An aluminium cup was recently made by the English firm, Thomas Fattorini, of Birmingham, for Alumina Jamaica Limited as an award at Jamaica's agricultural show. Made of spun-super-purity aluminium circles, it was polished, electro-brightened and anodized. The base of the cup is ebonized mahogany.

Electricity and Fuel Efficiency

Equipment and displays illustrating the important part which electricity plays both in the fields of fuel economy and productivity will be seen on the stand of the **Electrical Development Association** at the Industrial Fuel Efficiency Exhibition which is to be held at Olympia, London, from September 24 to October 3 next.

Industrial applications of electricity forming the exhibit will range from a high sensitivity thickness gauge, an electronic smoke density meter for indicating when a factory chimney is emitting black smoke, a battery electric truck for works use, a layout illustrating induction heating and quenching being carried out in the production line, to an example of a crucible furnace for process heating.

The latest forms of electric space heating appliances will also be shown in the form of block storage heaters, which store by night and heat by day. These contain large fireclay blocks embodying heating elements.

Mr. M. J. Glenny receiving a silver salver from Mr. R. L. Handley on the occasion of his retirement from the Presidency of the National Federation of Engineering and General Ironfounders

A Presentation

On Wednesday of last week, an interesting ceremony took place at the Great Northern Hotel, in London, when **Mr. Malcolm J. Glenny,** of the Dover Engineering Works Ltd., retiring President of the National Federation of Engineering and General Ironfounders, received a presentation which was made to him on behalf of the Federation by **Mr. R. Laroux Handley,** of Ferranti Ltd., the current President.

Mr. Glenny has been very active in his work on behalf of the Federation, and is also chairman of the Council of Ironfoundry Associations. Our photograph on this page shows him receiving a salver, suitably inscribed, from Mr. Handley, at last week's function.

Open Days

Work in progress at the **National Chemical Laboratory,** Teddington, may be seen during the "Open Days" which are to be held on Tuesday and Wednesday, October 21 and 22, this year. Applications from firms for invitations to the morning and afternoon sessions on these days should be addressed to the Director of the Laboratory not later than September 20 next.

Research and Service Facilities

In a publication entitled "Electroflo Service," **Electroflo Meters Co. Ltd.** outline the extent of their activities in the research, application engineering, installation-commissioning and maintenance fields for their complete range of instrumentation and automatic control equipment. Of particular importance is their fluid dynamics laboratory which, the company states, is used regularly by major plant manufacturers to investigate fluid flow problems, and also in the design of ducting, flow piping layouts, valves, etc.

Metal Finishing

A course of lectures on "Modern Developments in Metal Finishing" is being offered in the forthcoming Autumn term at the **Borough Polytechnic,** London, commencing on October 8 next. This course is organized to provide a detailed and up-to-date survey of some selected methods of metal finishing and related topics. These will include not only lectures in technological topics, but also in human relations in the plating industry, and costing. The fee for the course of eight lectures is £1.

Other courses being arranged by the Polytechnic are as follows:—A course in fuel technology in preparation for the examinations in this subject by the City and Guilds of London Institute. This course may be taken either on a part-time day or an evening basis.

Classes to be held on Monday evenings will cover the subject of fuel and combustion engineering. This course is being offered as an endorsement to the Higher National Certificate course in mechanical engineering. A course of lectures on oil burning technology will be held on Friday afternoons from 2.30 to 4.30. Full details of all these courses may be obtained from the Principal of the Polytechnic at Borough Road, London, S.E.1.

Electronic Digital Computers

In view of the established usage of electronic computers to scientific computation, and their potentialities in accountancy and other commercial procedures, the **Birmingham College of Technology** is organizing a series of one-day conferences on electronic digital computers and their industrial applications.

The first of this series, with special reference to Ferranti computers, will be held at the College at Gosta Green, Birmingham, on Wednesday, October 8 next. The speakers at the conference will be Mr. M. Jackson, M.Sc. (College of Technology); Mr. W. F. M. Payne, B.A.; Mr. F. Keay, M.A., A.C.I.S., and Dr. C. M. Wilson, B.Sc., Ph.D., all of Ferranti Ltd. The conference fee (including luncheon) is £2. Full details and application forms may be obtained from the Registrar, College of Technology, Gosta Green, Birmingham, 4.

U.K. Metal Stocks

Stocks of refined tin in London Metal Exchange official warehouses at the end of last week totalled 18,460 tons, comprising London 6,244; Liverpool 10,746; and Hull 1,470 tons. Copper stocks totalled 12,757 tons, and comprised London 7,024; Liverpool 5,458; Birmingham 75; Manchester 50, and Swansea 150 tons.

Philippine Copper Report

A total of 3,543,787·6 lb. of copper was produced by Atlas Consolidated Mining and Development Corporation, principal Philippine mining firm, during the month of June, it is reported in Manila. The company report stated that water shortage at the Toledo mine continued to hamper production and prevented the mill from treating more than 270,000 tons of ore during the month. The ore treated produced 6,777·465 dry short tons containing

3,543,787·6 lb. of copper. This compares with the May figure of 307,833 tons of ore treated, 7,404·2 dry short tons of concentrates produced, containing 3,900,730 lb. of copper.

Shipments of copper concentrates for June totalled 5,853.·5 dry short tons of copper concentrates containing 3,074,109 lb. of copper.

Lepanto Consolidated Mining Company, another principal copper producer in Manila, reported that it shipped recently to Tacoma, Washington, 9,068 wet metric tons of concentrates estimated to contain 5,112,940 lb. of copper.

The Marinduque Iron Mines, which produces copper concentrates, reported 2,857·68 dry metric tons (equivalent to 3,150·02 dry short tons) of copper concentrates produced in June from 132,717 dry metric tons of ore milled in its Sipalay mine in Negros Occidental, in the southern Philippines. At the company's Bagacay property (on Samar Island) 852 wet metric tons of copper ore with an average copper content of 15·60 per cent, having an approximate copper content of 273,210 lb. of copper, were mined.

A Demonstration

A number of Northern Ireland industrialists recently attended a three-day demonstration of oxy-acetylene flame cleaning equipment which was held at the Belfast works of **British Oxygen Gases Limited.** About 90 representatives from shipyards, engineering works, electrical, water and surveyors' departments, and the Gas undertaking attended, together with structural steel contractors, agricultural machinery and artificial fertilizer manufacturers, and representatives of the local Harbour Board.

Those attending saw practical demonstrations of the equipment, which is designed to remove mill scale and rust from steel and which also provides a warm surface so that paint will bond well and dry quickly. Following the demonstrations, a film on the process was shown and questions were then answered by Mr. J. Widdecombe, of the sales technical service department of the company.

German Output

West German production of non-ferrous metals showed no uniform trend in the first six months of the current year, according to preliminary statistics issued by the Government's Office of Statistics. Output of aluminium and zinc showed a substantial decline, while that of copper and lead was slightly higher than a year before. Production for the individual metals was as follows (metric tons with first half 1957 in brackets): aluminium 67,950 (78,097); copper 93,418 (88,464); zinc 87,969 (92,317); lead 88,152 (87,327).

Italian Copper Statistics

It is reported by the Italian Statistical Office that in the first four months of the current year, imports of crude copper for smelting and refining amounted to 1,756 metric tons, worth 557,583,000 lire, of which 501 metric tons was temporarily imported. Main origins were Indonesia with 101 metric tons and Chile with 1,553 tons. Imports of refined copper in slabs, ingots, granulated and powdered forms were 27,334 metric tons, valued at 8,501,222,000 lire, of which 4,765 tons were imported on a temporary basis. Main origins were Britain, with 2,960 tons; the Belgian Congo, with 4,088; Chile with 5,714, and the United States with 7,421 metric tons.

In the first five months of the current year, Italy imported 2,178 tons of copper scrap, compared with 7,074 tons in the comparable period of 1957.

U.S. Minerals Subsidy Bill

A House Interior Sub-Committee has approved a Senate-passed Minerals Subsidy Bill after voting slightly bigger Government lead and zinc payments. The measure would furnish Government price support for lead, zinc, tungsten and fluorspar, and would also authorize stockpiling of up to 150,000 tons of domestically-mined copper for one year at market prices up to 27½ cents per lb.

The Interior Department had told the Sub-Committee last week that the prices proposed for lead, zinc and fluorspar were too high, and that tungsten should be eliminated from the Bill. The Sub-Committee ignored these objections. It did, however, approve an Administration suggestion to add to the Bill a new provision providing incentive payments for producers of beryl-metallurgical grade chromite and columbium-tantalum.

Industrial Chemistry

In the first issue of a publication which they have entitled "Monsanto Mail," **Monsanto Chemicals Limited** seeks to show by articles and illustrations the part played by industrial chemistry in the life of communities. The many interesting articles which are contained in this first issue cover a wide range of subjects, but all are presented in an easily readable form and are accompanied by a number of high-class illustrations, many of them in colour.

Titanium Alloys

In a recently issued information sheet (No. M811), from **William Jessop and Sons Limited,** a number of interesting details relating to the corrosion-resisting characteristics of titanium alloys are given. It is stated that the data provided is primarily compiled from laboratory tests on commercially-pure titanium (Jessop qualities Hylite 10 and 15), and care must be taken in assessing service environments. In addition, even though laboratory tests indicate that alloying has little effect on the corrosion resistance of titanium, it is inadvisable to interpret this generally, and Jessop technical staff are available to advise on this question.

A Handling Problem

Arising from the introduction of **British Oxygen**'s range of cross-carriage flame cutting machines, including the "Bison," "Beagle" and "Oxyplane," their Equipment Division at Edmonton was faced with the problem of storing and handling batches of steel section of widely differing lengths and shapes. For a time, these were stored in floor compounds and handled by mobile crane. As stocks increased, however, this method proved to be uneconomical, and it was necessary to seek better means of space utilization and less costly handling methods in terms of both time and money.

To solve this problem, the firm introduced an "Irion" side lift fork carrier, and this was operated with horizontal side arm storage racks of a heavy type. The racks were made in the Edmonton works from heavy section steel joists and channels, and they provided storage capacity to a height of 14 ft. The truck operates without difficulty in a 7 ft. 6 in. aisleway despite the fact that its overall width is 6 ft.

U.S. Zinc and Copper

Production of rolled zinc in the United States during 1957 declined by 17 per cent to 39,700 short tons, the lowest output in 25 years, according to the Bureau of Mines, U.S. Department of the Interior. Output of strip and ribbon zinc was 25,900 tons, and that of boiler plate (over 0·1 in. thick) only 600 tons. Sheet zinc (not over 0·1 in. thick) production declined five per cent to 11,300 tons, and foil, rod and wire output totalled 1,900 tons or six per cent below 1956. Rolling mills used 41,300 tons of slab zinc and 400 tons of purchased scrap. In addition, 12,700 tons of strip, ribbon and sheet zinc were remelted and re-rolled from scrap originating in fabricating plants operating in connection with zinc rolling mills.

Domestic consumption of copper by brass and wire mills and foundries, based on their shipments of fabricated products, in June totalled 108,510 short tons, against 88,447 in May, according to the U.S. Copper Association. New business booked by fabricators in terms of refined copper to be used totalled 115,482 short tons, against 81,014. Unfilled orders on fabricators' books at the end of June totalled 145,162 short tons, against 138,190 a month earlier.

Fabricators' stocks of refined copper at the end of the month totalled 433,526 short tons, against 441,001 at the end of May, while orders on hand with producers amounted to 72,385 tons, against 78,194. Fabricators' receipts from producers were 100,296 short tons, against 78,631, and their gross reserves 505,911 short tons, against 519,915. Fabricators' working stocks at the end of June were 330,301 short tons, against 345,404 at the end of May.

Tin Council Meet

On Wednesday this week the International Tin Council met to consider, among other things, the fixing of export quotas for the fourth quarter of this year. As prices are again hovering around the £730 a ton support level after their short-lived advance at the start of the Middle East disturbances, it is expected that the quotas will remain unchanged.

During the session, the chairman is expected to report to the Council on his attempts to get Russia to join the International Tin Agreement as a producing member. The meeting is expected to continue until to-day, when a communique will be issued.

U.K. Platinum Price

With immediate effect, Baker Platinum has reduced its price of platinum from £25 to £23¼ per troy ounce. Baker last changed its price on May 12, when it was reduced from £26¼ to £25. In addition to continued offerings of Russian metal at competitive prices, trade quarters say that the reduced demand for the metal, especially from the petroleum industry, also contributed towards the decline. Moreover, open market prices have generally ruled at a considerable discount to the refiners' price. Dealers' open market ideas recently were £20 to £21.

We understand that Johnson, Matthey and Company will be quoting platinum at £23¼ per troy ounce, compared with £25 previously.

Metal Market News

THE base metal markets and, indeed, all the commodities, were last week completely under the influence of events in the Middle East, so that the trend of prices was dictated not by the volume of demand but by the news coming in hour by hour from the storm centres. Broadly speaking, when the stock markets recovered metal prices declined and vice versa. Dealing was fairly active but rather patchy and quite a fair tonnage was done on the Kerb. On Monday, the copper market opened firm on the news from Bagdad, and also on the report that the stockpile was a step nearer its adoption on the statute book. Moreover, L.M.E. stocks of copper were reported down by 325 tons to 13,157 tons. Following some keen buying, three months' copper at midday advanced to £199, or £3 10s. 0d. above the previous Friday's close, but in the afternoon values turned easier, and on the Kerb £197 15s. 0d. was paid. On the following day came news that 5,000 United States marines had landed in Lebanon, and on the afternoon market forward copper reached £200. The Belgian price was marked up 50 points to 28 francs on Wednesday, and the quotation at midday was £201 10s. 0d., but in the afternoon Kerb dealings there was a decline of about £2 10s. 0d. Thursday brought news of British paratroopers landing in Jordan, and the price leapt up to £205 10s. 0d. at midday. Other bullish news reported Kennecott up to 26½ cents, and the custom smelters at the same level. Moreover, the Belgians moved their price up again by 50 points to 28½ francs per kilo. On Friday, the market opened on a distinctly easier note, and the three months' position sold off to £201, from which point, however, a recovery set in. Finally, the week closed on Friday afternoon at £202 for cash, £7 higher than the previous Friday, while three months, at £203, was £7 10s. 0d. better. The turnover was 9,500 tons, but probably another 1,000 tons was done on the Kerb.

Both zinc and lead fluctuated somewhat, but tin, after hanging fire initially, went ahead to close £3 10s. 0d. up for cash but £7 10s. 0d. better for three months, at £734 and £738 10s. 0d. respectively. Keen bidding for the forward position widened the contango to £4 10s. 0d. The turnover, including Kerb business, amounted to about 800 tons. Last week saw the tin market assuming an appearance not seen for a long time past. As to lead and zinc, both these metals closed below the best but higher than a week earlier on balance. In lead, about 6,500 tons changed hands, with a gain of £1 15s. 0d. in July at £71 15s. 0d. and of £1 5s. 0d. in October at £73. Zinc returned a turnover of about 7,650 tons to close at £64 10s. 0d. July and £65 5s. 0d. October, these quotations registering gains of £2 5s. 0d. and £2 7s. 6d. respectively. It was certainly a good week for the bulls of all the metals.

The Copper Institute has published the June statistics in terms of short tons of 2,000 lb. These are given as follow: inside the U.S.A. production of crude copper was 82,076 tons, against 91,116 tons in May. Refined output at 107,474 was down by about 8,500 tons, but deliveries of refined copper jumped from 78,631 tons to 102,296 tons, the effect, perhaps, of consumers seeking to anticipate a higher price under the duty. Stocks of refined copper in producers' hands were 9,000 tons down at 244,420 tons. Outside the United States, the output of crude was 143,738 tons, compared with 138,461 tons in May, while in refined copper total output was 120,469 tons, about 10,600 tons up. Deliveries were about 5,800 tons up at 140,085, while stocks of refined copper at 232,402 tons compared with 245,053 tons at May 31.

Birmingham

For thousands of workers in the engineering and metal industries, this week-end sees the start of the annual fortnight's holiday. While the factories are idle a few firms will be stocktaking, and the opportunity will be taken to carry out major repairs which cannot be undertaken when works are in production. At the monthly meeting of the Regional Board for Industry, held last week, Major C. P. Dibben, chairman, said that, outside the motor industry, the general tendency in trade in the Midlands is slightly downward. Less overtime was being worked, conditions were more competitive, prices keener, profit margins smaller, and there had been a drop in public spending.

The iron and steel trade is quieter than it has been for some years, and no real upward movement is expected until the autumn. Consumers continue to reduce stocks and are only buying the bare minimum as far as requirements are concerned. The sheet mills have had an extremely good run of orders for the motor trade, and when holidays are over this business will be resumed on a good scale. The outlook for structural steel is uncertain. A good deal of reconstruction is in progress, but the steel for this was ordered long ago and new projects are very slow in coming forward. On the other hand, the easier position as far as money is concerned may encourage the revival of some building plans which have been shelved during the period of the credit squeeze.

According to the Board of Trade, 171 schemes for new factory building, involving 3·1 million ft^2 of factory space, were approved during the first half of this year, compared with 206 schemes for 5·6 million ft^2 in the same period of 1957. The relatively larger drop in floor area than in numbers of projects was reflected by the fact that smaller schemes are being submitted.

The Ministry of Works say that the load of building and civil engineering work in the Region is being maintained except for the general reduction in local authority housing. The amount of factory building work on the ground is still considerable. Local authority housing approvals are lower than a year ago, but private enterprise houses are being started at last year's rate. Other private building, such as shops and offices, show no marked tendency to decrease.

The amount of work being approved in the public sector is keeping on the high side, but the emphasis is on schemes in the field of road construction, opencast coal, and building work for the power industries. In the case of civil engineering work, the schemes coming forward are mainly of the larger type, and the civil engineering industry could take on more of the smaller type of work. In both the building and civil engineering fields there is very keen competition for contracts. Tender prices have to be pitched very low in order to secure contracts.

New York

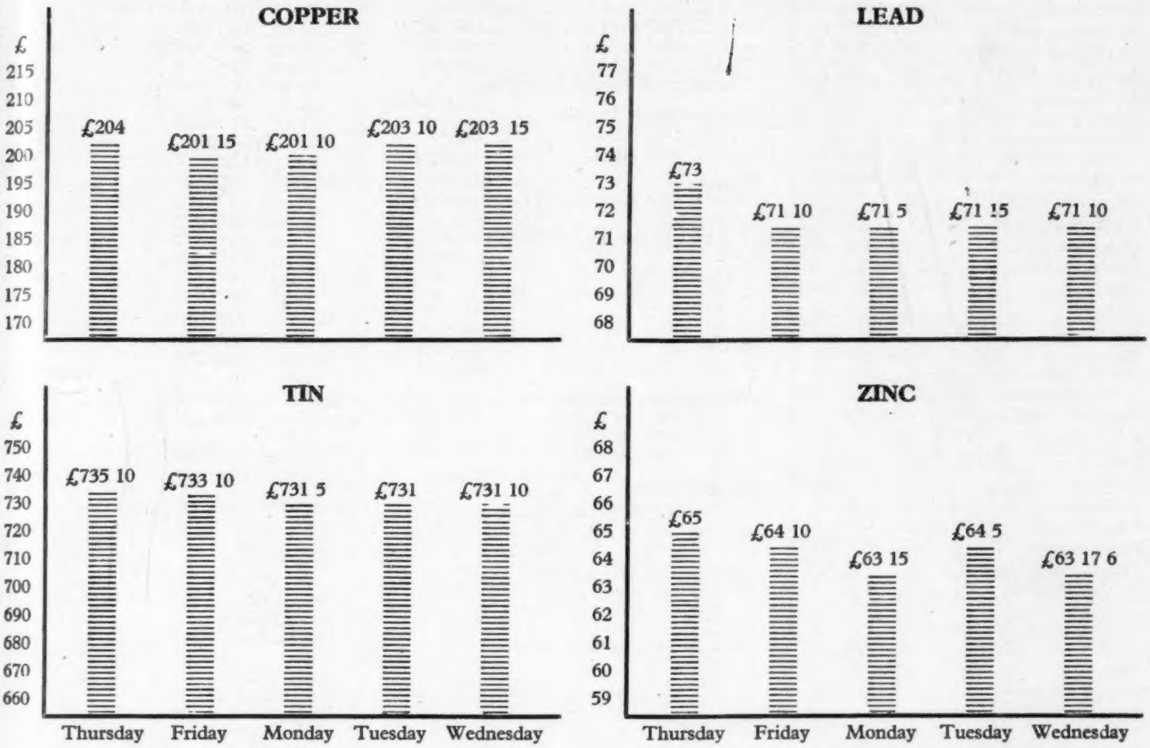
Custom smelters raised their price of copper half a cent to 26½ cents, making a single copper price in the market for the first time in months. Custom smelters reported that they were not active sellers at 26½ cents, but they cite tightness of incoming scrap and the high scrap copper price. One leading custom smelter indicated that he was not selling currently at a fixed price. Producers reported little change in their sales volume.

Tin was firm but inactive, with consumers withdrawn as buyers. One leading tin source said it appeared that active consumer buying in the past two days had adequately filled nearby needs of tinplaters. Lead and zinc were more active in some directions, stemming from Middle East incidents.

Mr. Royce A. Hardy, Assistant Secretary for Mineral Resources of the U.S. Department of the Interior, has endorsed the Senate Bill, now passed by the Senate, to pay subsidies to domestic producers of lead, zinc, fluorspar and tungsten. But he said the rates of payments were too high. He was testifying before the Minerals Sub-Committee of the House of Representatives Interior Committee.

METAL PRICE CHANGES

LONDON METAL EXCHANGE, Thursday 17 July 1958 to Wednesday 23 July 1958



OVERSEAS PRICES

Latest available quotations for non-ferrous metals with approximate sterling equivalents based on current exchange rates

	Belgium fr/kg ≏ £/ton		Canada c/lb ≏ £/ton		France fr/kg ≏ £/ton		Italy lire/kg ≏ £/ton		Switzerland fr/kg ≏ £/ton		United States c/lb ≏ £/ton	
Aluminium			22.50	185 17 6	210	182 15	375	217 10			26.10	208 17 6
Antimony 99.0					195	169 12 6	430	249 10			29.00	232 0
Cadmium					1,500	1,305 0					155.00	1,240 0
Copper												
Crude												
Wire bars 99.9							390	226 5				
Electrolytic	27.50	201 0	24.00	198 5	250	217 10			2.45	192 12 6	25.00	200 0
Lead			10.75	88 15	110	95 15	179	103 17 6	.87	77 15	11.00	88 0
Magnesium												
Nickel			70.00	578 5	1,205	1,048 7 6	1,300	754 0	7.80	652 5	74.00	592 0
Tin	102.00	745 10 6			896	779 10	1,400	812 0	8.60	719 2 6	93.87	751 0
Zinc												
Prime western			10.00	82 12 6							10.00	80 0
High grade 99.95			10.60	87 10 0								
High grade 99.99			11.00	90 5								
Thermic					107.12	93 2 6						
Electrolytic					115.12	100 2 6	157	91 0 0	.82	68 10	11.25	90 0

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NON-FERROUS METAL PRICES

(All prices quoted are those available at 12 noon 23/7/58)

PRIMARY METALS

		£	s.	d.
Aluminium Ingots	ton	180	0	0
Antimony 99·6%	„	197	0	0
Antimony Metal 99%	„	190	0	0
Antimony Oxide	„	180	0	0
Antimony Sulphide Lump	„	190	0	0
Antimony Sulphide Black Powder	„	205	0	0
Arsenic	„	400	0	0
Bismuth 99·95%	lb.		16	0
Cadmium 99·9%	„		10	0
Calcium	„	2	0	0
Cerium 99%	„	16	0	0
Chromium	„		6	11
Cobalt	„		16	0
Columbite	per unit		—	
Copper H.C. Electro.	ton	203	15	0
Fire Refined 99·70%	„	202	0	0
Fire Refined 99·50%	„	201	0	0
Copper Sulphate	„	70	0	0
Germanium	grm.		—	
Gold	oz.	12	10	6¼
Indium	„		10	0
Iridium	„	20	0	0
Lanthanum	grm.		15	0
Lead English	ton	71	10	0
Magnesium Ingots	lb.		2	5¼
Notched Bar	„		2	10¼
Powder Grade 4	„		6	3
Alloy Ingot, A8 or AZ91	„		2	8
Manganese Metal	ton	300	0	0
Mercury	flask	79	0	0
Molybdenum	lb.	1	10	0
Nickel	ton	600	0	0
F. Shot	lb.		5	5
F. Ingot	„		5	6
Osmium	oz.		nom.	
Osmiridium	„		nom.	
Palladium	„	5	15	0
Platinum	„	23	5	0
Rhodium	„	40	0	0
Ruthenium	„	16	0	0
Selenium	lb.		nom.	
Silicon 98%	ton		nom.	
Silver Spot Bars	oz.		6	3
Tellurium	lb.		15	0
Tin	ton	731	10	0
***Zinc**				
Electrolytic	ton		—	
Min 99·99%	„		—	
Virgin Min 98%	„	64	3	9
Dust 95/97%	„	104	0	0
Dust 98/99%	„	110	0	0
Granulated 99+%	„	89	3	9
Granulated 99·99+%	„	101	16	3

**Duty and Carriage to customers' works for buyers' account.*

INGOT METALS

Aluminium Alloy (Virgin)		£	s.	d.
B.S. 1490 L.M.5	ton	210	0	0
B.S. 1490 L.M.6	„	202	0	0
B.S. 1490 L.M.7	„	216	0	0
B.S. 1490 L.M.8	„	203	0	0
B.S. 1490 L.M.9	„	203	0	0
B.S. 1490 L.M.10	„	221	0	0
B.S. 1490 L.M.11	„	215	0	0
B.S. 1490 L.M.12	„	223	0	0
B.S. 1490 L.M.13	„	216	0	0
B.S. 1490 L.M.14	„	224	0	0
B.S. 1490 L.M.15	„	210	0	0
B.S. 1490 L.M.16	„	206	0	0
B.S. 1490 L.M.18	„	203	0	0
B.S. 1490 L.M.22	„	210	0	0

		£	s.	d.
†Aluminium Alloy (Secondary)				
B.S. 1490 L.M.1	ton	150	10	0
B.S. 1490 L.M.2	„	157	10	0
B.S. 1490 L.M.4	„	177	10	0
B.S. 1490 L.M.6	„	192	10	0

†Average selling prices for May

		£	s.	d.
***Aluminium Bronze**				
BSS 1400 AB.1	ton	205	0	0
BSS 1400 AB.2	„		—	
***Brass**				
BSS 1400-B3 65/35	„	139	0	0
BSS 249	„	150	0	0
BSS 1400-B6 85/15	„		—	
***Gunmetal**				
R.C.H. 3/4% ton	ton		—	
(85/5/5/5)	„	169	0	0
(86/7/5/2)	„	178	0	0
(88/10/2/1)	„	227	0	0
(88/10/2/½)	„	242	0	0
Manganese Bronze				
BSS 1400 HTB1	„	171	0	0
BSS 1400 HTB2	„		—	
BSS 1400 HTB3	„		—	
Nickel Silver				
Casting Quality 12%	„		nom.	
„ „ 16%	„		nom.	
„ „ 18%	„		nom.	
***Phosphor Bronze**				
2B8 guaranteed A.I.D. released	„	253	0	0
Phosphor Copper				
10%	„	220	0	0
15%	„	227	0	0

**Average prices for the last week-end.*

		£	s.	d.
Phosphor Tin				
5%	ton		—	
Silicon Bronze				
BSS 1400-SB1	„		—	
Solder, soft, BSS 219				
Grade C Tinmans	„	345	6	0
Grade D Plumbers	„	279	6	0
Grade M	„	378	6	0
Solder, Brazing, BSS 1845				
Type 8 (Granulated)	lb.		—	
Type 9	„		—	
Zinc Alloys				
Mazak III	ton	95	1	3
Mazak V	„	99	1	3
Kayem	„	105	1	3
Kayem II	„	111	1	3
Sodium-Zinc	lb.		2	5

SEMI-FABRICATED PRODUCTS

Prices of all semi-fabricated products vary according to dimensions and quantities. The following are the basis prices for certain specific products.

Aluminium		£	s.	d.
Sheet 10 S.W.G.	lb.		2	8
Sheet 18 S.W.G.	„		2	10
Sheet 24 S.W.G.	„		3	1
Strip 10 S.W.G.	„		2	8
Strip 18 S.W.G.	„		2	9
Strip 24 S.W.G.	„		2	10¼
Circles 22 S.W.G.	„		3	2
Circles 18 S.W.G.	„		3	1
Circles 12 S.W.G.	„		3	0
Plate as rolled	„		2	7¼
Sections	„		3	1¼
Wire 10 S.W.G.	„		2	11
Tubes 1 in. o.d. 16 S.W.G.	„		4	0

		£	s.	d.
Aluminium Alloys				
BS1470. HS10W.	lb.			
Sheet 10 S.W.G.	„		3	0¼
Sheet 18 S.W.G.	„		3	3
Sheet 24 S.W.G.	„		3	10¼
Strip 10 S.W.G.	„		3	0¼
Strip 18 S.W.G.	„		3	2
Strip 24 S.W.G.	„		3	10
BS1477 HP30M.				
Plate as rolled	„		2	10¼
BS1470. HC15WP.				
Sheet 10 S.W.G.	lb.		3	6¼
Sheet 18 S.W.G.	„		4	0¼
Sheet 24 S.W.G.	„		4	10¼
Strip 10 S.W.G.	„		3	9¼
Strip 18 S.W.G.	„		4	0¼
Strip 24 S.W.G.	„		4	8
BS1477. HPC15WP.				
Plate heat treated	„		3	5¼
BS1475. HG10W.				
Wire 10 S.W.G.	„		3	9¼
BS1471. HT10WP.				
Tubes 1 in. o.d. 16 S.W.G.	„		4	11
BS1476. HE10WP.				
Sections	„		3	1
Beryllium Copper				
Strip	„	1	4	11
Rod	„	1	1	6
Wire	„	1	4	9
Brass Tubes	„		1	7½
Brazed Tubes	„		—	
Drawn Strip Sections	„		—	
Sheet	ton		—	
Strip	„	225	0	0
Extruded Bar	lb.		1	9⅞
Extruded Bar (Pure Metal Basis)	„		—	
Condenser Plate (Yellow Metal)	ton	165	0	0
Condenser Plate (Naval Brass)	„	176	0	0
Wire	lb.		2	5
Copper Tubes	lb.		1	11⅞
Sheet	ton	230	5	0
Strip	„	230	5	0
Plain Plates	„		—	
Locomotive Rods	„		—	
H.C. Wire	„	252	15	0
Cupro Nickel				
Tubes 70/30	lb.		3	4½
Lead Pipes (London)	ton	113	15	0
Sheets (London)	„	111	10	0
Tellurium Lead	„	£6 extra		
Nickel Silver				
Sheet and Strip 7%	„		3	3¾
Wire 10%	„		3	9¾
Phosphor Bronze				
Wire	„		3	9

Titanium (1,000 lb. lots)			
Billet over 4″ dia.-18″ dia.	lb.	63/-	64/-
Rod 4″ dia. - ·250″ dia.	„	75/-	112/-
Wire under ·250″ diam. - ·036″ diam.	„	146/-	222/-
Sheet 8′×2′×·250″-·010″ thick	„	88/-	157/-
Strip ·048″-·003″ thick	„	100/-	350/-
Tube (representative gauge)	„		300/-
Extrusions	„		120/-

		£	s.	d.
Zinc Sheets, English destinations	ton	98	10	0
Strip	„		nom.	

Scrap Metal Prices

Merchants' average buying prices delivered, per ton, 22/7/58.

	£
Aluminium	
New Cuttings	134
Old Rolled	110
Segregated Turnings	90
Brass	
Cuttings	125
Rod Ends	122
Heavy Yellow	107
Light	102
Rolled	117
Collected Scrap	103
Turnings	116
Copper	
Wire	172
Firebox, cut up	168
Heavy	164
Light	159
Cuttings	172
Turnings	156
Braziery	136

	£
Gunmetal	
Gear Wheels	165
Admiralty	165
Commercial	138
Turnings	133
Lead	
Scrap	62
Nickel	
Cuttings	—
Anodes	420
Phosphor Bronze	
Scrap	138
Turnings	133
Zinc	
Remelted	54
Cuttings	41
Old Zinc	31

The latest available scrap prices quoted on foreign markets are as follow. (The figures in brackets give the English equivalents in £1 per ton):—

West Germany (D-marks per 100 kilos):		
Used copper wire	(£169.12.6)	195
Heavy copper	(£165.7.6)	190
Light copper	(£148.0.0)	170
Heavy brass	(£108.15.0)	125
Light brass	(£82.12.6)	95
Soft lead scrap	(£61.0.0)	70
Zinc scrap	(£34.17.6)	40
Used aluminium unsorted	(£87.0.0)	100
France (francs per kilo):		
Copper	(£208.17.6)	240
Heavy copper	(£208.17.6)	240
Light brass	(£143.10.0)	165
Zinc castings	(£65.5.0)	75
Lead	(£82.12.6)	95
Tin	(£565.10.0)	650
Aluminium	(£117.10.0)	135

Italy (lire per kilo):		
Aluminium soft sheet clippings (new)	(£191.10.0)	330
Aluminium copper alloy	(£113.2.6)	195
Lead, soft, first quality	(£84.12.6)	146
Lead, battery plates	(£49.17.6)	86
Copper, first grade	(£188.10.0)	325
Copper, second grade	(£177.0.0)	305
Bronze, first quality machinery	(£188.10.0)	325
Bronze, commercial gunmetal	(£159.10.0)	275
Brass, heavy	(£130.10.0)	225
Brass, light	(£119.0.0)	205
Brass, bar turnings	(£127.12.6)	220
New zinc sheet clippings	(£55.2.6)	95
Old zinc	(£40.12.6)	70

Financial News

Murex Limited

Group profits £983,000 (£1,021,000); taxation £432,000 (£446,000); net profits £291,000 (£352,000); forward £137,000 (£123,000). Final dividend 10 per cent, making 17½ per cent for the year (20 per cent).

New Companies

The particulars of companies recently registered are quoted from the daily register compiled by Jordan and Sons Limited, Company Registration Agents, Chancery Lane, W.C.2.

A. G. Clowes and Co. Limited (604392), 10 Bower Spring, Sheffield. Registered May 12, 1958. To carry on business of scrap dismantlers, dealers in virgin and scrap metals, etc. Nominal capital, £1,000 in £1 shares. Directors: Ernest Moore and Lionel Stevenson.

B. Richardson Limited (604940), 49 Milton Avenue, E.6. Registered May 21, 1958. To carry on business of furnace and boiler setters, refractory repairs and renewals to boilers, etc. Nominal capital, £200 in £1 shares. Directors: Bert Richardson and Mrs. Mabel E. Richardson.

C. Herd Limited (604943), Sawmill Garage, Station Road, Haydock, Lancs. Registered May 21, 1958. To carry on business of dealers in coal, coke, ore, metal and mineral substances, timber merchants, etc. Nominal capital, £1,000 in £1 shares. Permanent directors: Charles E. Herd and John Herd.

Hygrade Refractories Limited (605049), 3-4 Clements Inn, Strand, W.C.2. Registered May 23, 1958. To carry on business of manufacturers of and dealers in industrial refractories, etc. Nominal capital, £100 in £1 shares. Permanent directors: Paul V. Edwards and Reginald G. Cramphorn.

J. K. Wood Limited (605161), 13-19 Banbury Street, Birmingham, 5. Registered May 27, 1958. To carry on business of electro and chromium platers, etc. Nominal capital, £1,000 in £1 shares. Directors: John K. Wood and Mrs. Gladys M. Wood.

Barker and Rone Limited (605376), 59-60 Tower Street, Hockley, Birmingham, 19. Registered May 30, 1958. To carry on business of welders, etc. Nominal capital, £2,000 in £1 shares. Directors: Douglas E. Graham and Jean E. Graham.

Mansfield Plating Company Limited (605490), Pembroke Street, Mansfield, Notts. Registered June 2, 1958. To carry on business of electro, nickel and chromium platers, etc. Nominal capital, £1,000 in £1 shares. Directors: Roger Jarvis and Mrs. Bessie Jarvis.

Trade Publications

Gas-Fire Furnaces.—The Incandescent Heat Company Ltd., Cornwall Road, Smethwick, Birmingham.

A new leaflet deals with this company's standard gas-fire furnaces which are considered ideal for general purpose heat treatment—normalizing, annealing, pack carburizing, reheating for refining, hardening, tempering, and other processes within the temperature range 600°C. to 1,000°C. Careful design of burner equipment and furnace structure ensures temperature uniformity. To give rapid heating from cold and to reduce thermal losses, the furnace chamber is lined with best quality hot face insulating bricks, backed by insulating materials.

A British Chemicals Group.—Albright and Wilson Ltd., 1 Knightsbridge Green, London, S.W.1.

A pleasantly produced booklet entitled "Facts about Albright and Wilson" has been issued by this company. Illustrated by numerous halftones, the booklet is printed in three colours and describes very briefly the structure of the Albright and Wilson Group of companies and the activities of some of the larger manufacturing companies within the group. In addition to mentioning production of the group in this country, overseas operations are also briefly described, and future expansions are mentioned. The booklet is available also in a German edition, and copies may be obtained from the publicity department of the group.

Aluminium Chart.—Stedall and Company Ltd., 164 High Holborn, London, W.C.1.

This large wall chart gives details and illustrations of the wide range of aluminium sections, sheets and plates provided by this company. In addition to the stock range shown, the chart includes a new range of light alloy sections designed to form the basis of flat platform and dropside bodies which can be economically and speedily built.

Protective Clothing.—J. E. Lesser and Sons Ltd., Green Lane, Hounslow, Middx.

A useful little booklet is provided giving details of the range of "Jeltek" protective clothing produced by this company. The clothing described and illustrated covers the requirements of many industries, particularly engineering.

Heat-Treatment. — Brayshaw Furnaces and Tools Ltd., Belle Vue Works, Boundary Street, West Gorton, Manchester, 12.

Two useful leaflets are published by this company. One deals with their gas-fired shaker hearth furnace for the continuous heat-treatment of ferrous and non-ferrous parts — bright hardening, carbon restoration, gas carburizing, carbonitriding, etc. This furnace is compact in design, takes up a minimum of shop space, and is simple and straightforward in operation. The second leaflet deals with the gas-fire "Hynor" oven furnace, which is supplied for operating at temperatures in the range 650-1,000°C. or 650-1,200°C. without the use of pressure air. In certain instances, low capacity burners can be fitted which enable temperatures in the region of 450-650°C. to be obtained. In both these leaflets diagrams and illustrations are included.

THE STOCK EXCHANGE

Business Slack And Prices Uncertain

ISSUED CAPITAL ●	AMOUNT OF SHARE	NAME OF COMPANY	MIDDLE PRICE 22 JULY	+RISE —FALL	DIV. FOR LAST FIN. YEAR	DIV. FOR PREV. YEAR	DIV. YIELD	1958 HIGH	1958 LOW	1957 HIGH	1957 LOW
£	£				Per cent	Per cent					
4,435,792	1	Amalgamated Metal Corporation	20/9		9	10	8 13 6	21/3	17/9	28/3	18/-
400,000	2/-	Anti-Attrition Metal	1/6		4	8½	5 6 9	1/6	1/3	2/6	1/6
33,639,483	Stk. (£1)	Associated Electrical Industries	50/-		15	15	6 0 0	51/-	47/-	72/3	47/9
1,590,000	1	Birfield Industries	51/6	—6d.	15	15	5 16 6	53/9	46/3	70/-	48/9
3,196,667	1	Birmid Industries	68/3	—6d.	17½	17½	5 2 6	68/9	56/3	80/6	55/9
5,630,344	Stk. (£1)	Birmingham Small Arms	27/6	+3d.	10	8	7 5 6	28/6	23/9	33/-	21/9
203,150	Stk. (£1)	Ditto Cum. A. Pref. 5%	15/4½		5	5	6 10 0	15/7½	14/7½	16/-	15/-
350,580	Stk. (£1)	Ditto Cum. B. Pref. 6%	16/7½		6	6	7 4 3	17/-	16/6	19/-	16/6
500,000	1	Bolton (Thos.) & Sons	25/-		12½	12½	10 0 0	28/9	25/-	30/3	28/9
300,000	1	Ditto Pref. 5%	15/-	—6d.	5	5	6 13 3	16/-	15/-	16/9	14/3
160,000	1	Booth (James) & Co. Cum. Pref. 7%	19/4½		7	7	7 4 6	19/4½	19/-	22/3	18/9
9,000,000	Stk. (£1)	British Aluminium Co.	47/-	+2/3	12	12	5 2 3	47/-	37/-	72/-	38/3
1,500,000	Stk. (£1)	Ditto Pref. 6%	19/-		6	6	6 6 3	19/3	18/4½	21/6	18/-
15,000,000	Stk. (£1)	British Insulated Callender's Cables	41/3	—1/3	12½	12½	6 1 3	45/6	38/9	55/-	40/-
17,047,166	Stk. (£1)	British Oxygen Co. Ltd., Ord.	36/3	+2/6	10	10	5 10 6	36/3	29/-	39/-	29/6
600,000	Stk. (5/-)	Canning (W.) & Co.	19/10½	—1½d.	25+*2½C	25	6 5 9	21/-	19/7½	24/6	19/3
60,484	1/-	Carr (Chas.)	1/9		25	25	10 0 0X	2/3	1/9	3/6	2/1½
150,000	2/-	Case (Alfred) & Co. Ltd.	4/1½		25	25	12 2 6	4/9	4/1½	4/6	4/-
555,000	1	Clifford (Chas.) Ltd.	19/-		10	10	10 10 6	19/-	16/-	20/6	15/9
45,000	1	Ditto Cum. Pref. 6%	15/9		6	6	7 12 6	15/10½	15/7½	17/6	16/-
250,000	2/-	Coley Metals	2/9		20	25	14 11 0	4/6	2/9	5/7½	3/9
8,730,596	1	Cons. Zinc Corp.†	49/9	+2/-	18¾	22½	7 10 9	51/6	42/6	92/6	49/-
1,136,233	1	Davy & United	52/3		15	12½	5 14 9	52/3	45/9	60/6	42/6
2,750,000	5/-	Delta Metal	19/3		30	*17½	7 15 9	21/4½	17/7½	28/6	19/-
4,160,000	Stk. (£1)	Enfield Rolling Mills Ltd.	32/6	—1/6	12½	15B	7 13 6	34/-	24/-	38/6	25/-
750,000	1	Evered & Co.	27/6xcap		15Z	15	7 5 6	28/3	26/-	52/9	42/-
18,000,000	Stk. (£1)	General Electric Co.	32/3	—1½d.	12½	14	7 2 9Y	38/7½	29/6	59/-	38/-
1,500,000	Stk. (10/-)	General Refractories Ltd.	30/9	—6d.	20	17½	6 10 0	33/9	27/3	37/-	26/9
401,240	1	Gibbons (Dudley) Ltd.	63/-		15	15	4 15 3	66/3	63/-	71/-	53/-
750,000	5/-	Glacier Metal Co. Ltd.	5/6		11½	11½	10 9 3	6/6	5/6	8/1½	5/10½
1,750,000	5/-	Glynwed Tubes	14/-		20	20	7 2 9	14/1½	12/10½	18/-	12/6
5,421,049	10/-	Goodlass Wall & Lead Industries	23/6	—3d.	13‖	18Z	5 10 9	24/6	19/3	37/3	28/9
342,195	1	Greenwood & Batley	49/3		20	17½	8 2 6	49/3	45/-	50/-	46/-
396,000	5/-	Harrison (B'ham) Ord.	13/3	—3d.	*15	*15	5 13 3	13/6	11/6	16/9	12/4½
150,000	1	Ditto Cum. Pref. 7%	19/-		7	7	7 7 3	19/-	18/9	22/3	18/7½
1,075,167	5/-	Heenan Group	7/3		10	20‡	6 18 0	7/7½	6/9	10/4½	6/9
216,531,615	Stk. (£1)	Imperial Chemical Industries	29/1½	+1/6	12Z	10	5 9 9	30/4½	27/7½	46/6	36/3
33,708,769	Stk (£1)	Ditto Cum. Pref. 5%	16/-	—3d.	5	5	6 5 0	17/1½	16/-	18/6	15/6
14,584,025	**	International Nickel	147½	+9½	$3.75	$3.75	4 17 0	148½	132¾	222	130
430,000	5/-	Jenks (E. P.), Ltd.	7/6	—3d.	27½ϕ	27½	9 3 3	8/3	6/9	18/10½	15/1½
300,000	1	Johnson, Matthey & Co. Cum. Pref. 5%	16/3		5	5	6 3 0	16/3	15/-	17/-	14/6
3,987,435	1	Ditto Ord.	37/-xd	+3d.	10	10	5 8 0	44/-	37/-	58/9	40/-
600,000	10/-	Keith, Blackman	20/-xd	+10½d.	17½	15	8 15 0	20/-	15/-	21/9	15/-
160,000	4/-	London Aluminium	4/3		10	10	9 8 3	4/4½	3/-	6/9	3/6
2,400,000	1	London Elec. Wire & Smith's Ord.	44/3	—9d.	12½	12½	5 13 0	45/-	39/9	54/6	41/-
400,000	1	Ditto Pref.	23/3		7½	7½	6 9 0	23/3	22/3	25/3	21/9
765,012	1	McKechnie Brothers Ord.	34/-		15	15	8 16 6	35/-	32/-	48/9	37/6
1,530,024	1	Ditto A Ord.	33/-		15	15	9 1 9	33/-	30/-	47/6	36/-
1,108,268	5/-	Manganese Bronze & Brass	9/9	+3d.	20	27½‡	10 5 3	10/6	9/-	21/10½	7/6
50.628	6/-	Ditto (7½% N.C. Pref.)	5/9		7½	7½	7 16 6	6/3	5/9	6/6	5/-
13,098,855	Stk. (£1)	Metal Box	53/6	—9d.	11	11	4 2 3	54/3	41/9	59/-	40/3
415,760	Stk. (2/-)	Metal Traders	7/1½		50	50	14 0 9	7/1½	6/3	8/-	6/3
160,000	1	Mint (The) Birmingham	19/-		10	10	10 10 6	22/9	19/-	25/-	21/6
80,000	5	Ditto Pref. 6%	79/6		6	6	7 11 0	83/6	79/6	90/6	83/6
3,705,670	Stk. (£1)	Morgan Crucible A	38/-		10	10	5 5 3	40/-	34/-	54/-	35/-
1,000,000	Stk. (£1)	Ditto 5½% Cum. 1st Pref.	17/3		5½	5½	6 7 6	17/3	17/-	19/3	16/-
2,200,000	Stk. (£1)	Murex	51/-	—3/-	17½	20	6 17 3	58/9	51/-	79/9	57/-
468,000	5/-	Ratcliffs (Great Bridge)	8/6		10	10	5 17 9	8/7½	6/10½	8/-	6/10½
234,960	10/-	Sanderson Bros. & Newbould	25/6	+1/-	20	27½D	7 16 9	27/-	24/6	41/-	24/9
1,365,000	Stk. (5/-)	Serck	13/7½	+3d.	17½Z	15	4 5 6	13/7½	11/-	18/10½	11/6
600,400	Stk. (£1)	Stone (J.) & Co. (Holdings)	52/6	—1/6	18	16	6 17 3	54/-	43/9	57/6	43/9
600,000	1	Ditto Cum. Pref. 6½%	23/6		6½	6½	5 10 9	23/6	19/6	21/9	18/9
14,494,862	Stk. (£1)	Tube Investments Ord.	55/3	+6d.	15	15	5 8 6	55/9	48/4½	70/9	50/6
41,000,000	Stk. (£1)	Vickers	31/10½	+1/10½	10	10	6 13 3	32/6	28/9	46/-	29/-
750,000	Stk. (£1)	Ditto Pref. 5%	15/-		5	5	6 13 3	15/6	14/9	18/-	14/-
6,863,807	Stk. (£1)	Ditto Pref. 5% tax free	21/9		*5	*5	7 2 6A	23/-	21/3	24/9	20/7½
2,200,000	1	Ward (Thos. W.), Ord.	78/6	—6d.	20	15	5 2 0	79/-	70/9	83/-	64/-
2,666,034	Stk. (£1)	Westinghouse Brake	38/-	—3d.	10	18P	5 5 3	40/-	32/6	85/-	29/1½
225,000	2/-	Wolverhampton Die-Casting	7/1½	—1½d.	25	40	7 0 3	8/-	7/1½	10/1½	7/-
591,000	5/-	Wolverhampton Metal	18/-	+3d.	27½	27½	7 12 9	18/-	14/9	22/3	14/9
78,465	2/6	Wright, Bindley & Gell	3/7½	+1½d.	20	17½E	13 15 9	3/9½	3/3	3/9	2/7½
124,140	1	Ditto Cum. Pref. 6%	11/6		6	6	10 8 9	11/6	11/3	12/6	11/3
150,000	1/-	Zinc Alloy Rust Proof	2/10½xd		27	40D	9 7 9	3/1½	2/7½	5/-	2/9

*Dividend paid free of Income Tax. †Incorporating Zinc Corpn. & Imperial Smelting **Shares of no Par Value. ‡ and 100% Capitalized Issue. ●The figures given relate to the issue quoted in the third column. A Calculated on £7 14 6 gross. Y Calculated on 11¼% dividend. ‖Adjusted to allow for capitalization issue. E for 15 months. P and 100% capitalized issue, also "rights" issue of 2 new shares at 35/- per share for £3 stock held. D and 50% capitalized issue. Z and 50% capitalized issue. B equivalent to 12½% on existing Ordinary Capital after 100% capitalized issue. ϕ And 100% capitalized issue. X Calculated on 17½%. C Paid out of Capital Profits.